A Workshop on
Building Capability and Communities
in Engineering Education Research

sponsored by

in partnership with

Mérida—Yucatán, México • June 19, 2009

Monica F. Cox
Purdue University

Rocío Chavela Guerra
Purdue University
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
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

<table>
<thead>
<tr>
<th>Category</th>
<th>Informal Research</th>
<th>Formal Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation and purpose</td>
<td>Improve teaching and learning of the 2nd law in my thermo class</td>
<td>Identify basic processes of understanding the 2nd law including common misconceptions held by different learners</td>
</tr>
<tr>
<td>Question to be answered</td>
<td>Why don't my students remember how to use the 2nd law from their pre-requisite thermo course?</td>
<td>What misconceptions about the 2nd law and its implications about energy quality arise as students learn about it and attempt to apply it?</td>
</tr>
<tr>
<td>Use of the education research literature</td>
<td>Teaching practice literature from books and articles used to inform thinking about classroom approaches</td>
<td>Evidence-based literature from education (including engineering education) to explore relevant theories and use theoretical frameworks to design study and explain results</td>
</tr>
<tr>
<td>Feedback sought and given with colleagues</td>
<td>Informally with interested colleagues</td>
<td>Through peer review process for conferences and journals on engineering education</td>
</tr>
<tr>
<td>Study site</td>
<td>Instructor's thermo class</td>
<td>Students studied in clinical settings across institutions and contexts</td>
</tr>
<tr>
<td>Sampling</td>
<td>The entire class</td>
<td>Representative sample of students chosen according to quantitative (random, controlled) or qualitative (purposeful) research</td>
</tr>
</tbody>
</table>
# Informal vs. Formal Research

<table>
<thead>
<tr>
<th>Category</th>
<th>Informal Research</th>
<th>Formal Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human subjects in research (IRB approval)</td>
<td>None or expedited review</td>
<td>Yes</td>
</tr>
<tr>
<td>Measurement tools/methods</td>
<td>Classroom assessment techniques and surveys; exam questions</td>
<td>Appropriate methods for experimental, quasi-experimental or naturalistic design</td>
</tr>
<tr>
<td>Data analysis</td>
<td>Student opinion and satisfaction; pre-post comparison of student performance</td>
<td>Multiple forms of data analysis (statistical or text) to inform research question</td>
</tr>
<tr>
<td>Reporting of results</td>
<td>Anecdotally with colleagues; at regional or national engineering education conferences and conference proceedings</td>
<td>Archival education research literature</td>
</tr>
<tr>
<td>Impact on engineering education</td>
<td>Informs the individual faculty member and other faculty members; improves learning of future students</td>
<td>Informs the education research community in engineering and other fields</td>
</tr>
<tr>
<td>Transferability</td>
<td>Other engineering educators teaching thermodynamics and related topics</td>
<td>Education and engineering communities</td>
</tr>
</tbody>
</table>

Source: [RREE-comparative organizer of engr ed research version 2.xls](http://www.ce.umn.edu/~smith/ndlinks.html)
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)

http://inside.mines.edu/research/cee/ND.htm
Research can be inspired by …

<table>
<thead>
<tr>
<th>Understanding (Basic)</th>
<th>Use (Applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Pure basic research (Bohr)</td>
</tr>
<tr>
<td>No</td>
<td>Pure applied research (Edison)</td>
</tr>
</tbody>
</table>
Follow-up proposal has been awarded (RREE2)

- Includes a series of 5 short courses
  1) Fundamentals of Educational Research
  2) Identifying Theoretical Frameworks
  3) Designing Your Research Study
  4) Collaborating with Learning and Social Scientists
  5) Understanding Qualitative Research
- To be available on the WWW as they become available
Today’s objectives

1) Identify principal features of engineering education research

2) Frame and situate research questions and methodologies

3) Gain familiarity with several print and online resources

4) 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 education research look like?

- What are the qualities, characteristics, or standards for high-quality education research?

  Individually, list:

  1) Which qualities, characteristics, or standards identified so far DO NOT apply?

  2) What qualities, characteristics, or standards can you envision that are DIFFERENT for education research?

    As a group, combine your lists.
What does education research look like?

• (DO NOT apply list)  

• (DIFFERENT list)
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
Objective 2

Frame and situate research questions and methodologies
Theoretical frameworks

• **Why frameworks are important?**
  
  – Discuss your ideas with your neighbor

• **Frameworks can be adapted from multiple disciplines**
  
  – Psychology
  – Sociology
  – Anthropology
# Common frameworks in educational research

## Theories of learning
- Behavior theory
- Observational learning
- Cognitive: Information processing
- Cognitive: Constructivist
- Socio-constructivist

## Theories of motivation
- Behavior theory
- Cognitive: Self-efficacy
- Cognitive: Task value
- Cognitive: Self-determination
- Cognitive: Goal orientation

## Theories of development
- Piagetian cognitive development
- Perry’s intellectual development
- Baxter-Magolda’s gender-related ways of knowing
- King and Kitchener’s Reflective judgment model

## Theories of contextual effects
- Situated Learning and Transfer
- Disciplinary differences in learning
- Desirable difficulties and learning
- Distributed cognition and the value of negotiating meaning during learning

See Marilla Svinick’s slides—Conceptual frameworks: Finding a conceptual framework that is appropriate for your question. [RREE-D2-Marilla-conceptual1.ppt](http://www.ce.umn.edu/~smith/ndlinks.html)
Which comes first: framework or observation?

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.
Which comes first: framework or observation?

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.
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.
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)
- Annals of Research on Engineering Education (AREE)
- Thomson ISI Citation Index
- Some other journals
A growing global journal
8,500 subscribers, 70 countries, 5 partners

- **Founded in 1910**
  - “technical” journal/magazine for 80 years
  - mission refined in 1993 and again in 2003

- **Mission**
  - “serve as an archival record of scholarly research in engineering education”

- **Manuscript types**
  - Research investigations
  - Research reviews

- **Six review criteria**

**NOTE!**
“The Relationships Between Students’ Conceptions of Learning and Their Preferences for Classroom and Laboratory Learning Environments,” by Chia-Ching Ling and Chin-Chung Tsai, National Taiwan University of Science and Technology, to appear in the *Journal of Engineering Education*, April 2009
AREE

www.areeonline.org

- Link journals related to engineering education
- Increase progress toward shared consensus on quality research
- Increase awareness and use of engineering education research
- Increase discussion of research and its implications

**Resources - community recommended**
- Annotated bibliography
- Acronyms explained
- Conferences, professional societies, etc.

**Articles - education research**
- Structured summaries
- Reflective essays
- Reader comments
Thomson ISI Citation Index

- **Thomson ISI** (Institute for Scientific Information)
- **Science Citation Index**
  - Category: Education, Scientific Disciplines
  - 23 journals in medicine (10), engineering (7), and science (6)
- **Social Science Citation Index**
  - Category: Education and Educational Research
  - 105 journals, including education (52), social sciences (28), natural science (9), medicine (6), engineering (1, JEE), other (9)
Some more journals

Where you can find articles on research in engineering and technology*

- Chronicle of Higher Education (http://chronicle.com/)
- Cognitive Science (http://www.cognitivesciencesociety.org/about.html)
- Cognition and Instruction (http://www.jstor.org/journals/07370008.html)
- College Teaching
- Cultural Studies in Science Education
- Design Studies (http://www.sciencedirect.com/science/journal/0142694X)
- Education Researcher (http://www.jstor.org/journals/0013189X.html)
- Journal of Higher Education (http://logon.jstor.org/journals/00221546.html)
- Interdisciplinary Journal of Knowledge and Learning Objects (http://ijklo.org/)
- International Journal for the Scholarship of Teaching and Learning (http://www.georgiasouthern.edu/ijsotl/)
- International Journal of Computer-Supported Collaborative Learning (http://ijcscl.org)
- International Journal of Problem-Based Learning (http://docs.lib.purdue.edu/ijpbl/)
- International Journal of Science and Mathematics Education (link: Int'l Journal of Science and Mathematics Education)
- Journal of the First-Year Experience
- Journal of the Learning Sciences (http://www-static.cc.gatech.edu/computing/lst/jls/)
- Journal of Engineering Education (http://www.asee.org/jee)
- Journal of Higher Education (http://www.jstor.org/journals/00221546.html)
- Mind, Culture, and Activity (http://lchc.ucsd.edu/MCA/Journal/index.html)
- Review of Higher Education (http://www.press.jhu.edu/journals/review_of_higher_education/)
- Science & Education
- Students in Transition

*Source: Noemi Mendoza-Diaz & James Cawthorne, School of Engineering Education, Purdue University, 9 December 2008
Some more journals

… with engineering or technology in their titles*
(mostly focused on curriculum development and position papers)

- Chemical Engineering Education
- Engineering Education: Journal of the Higher Education Academy Engineering Subject Centre
- European Journal of Engineering Education (http://www.tandf.co.uk/journals/titles/03043797.asp)
- IEEE Transactions on Education
- International Journal of Electrical Engineering Education (http://journals.mup.manchester.ac.uk/cgi-bin/MUP?COMval=journal&key=IJEEE)
- International Journal of Engineering Education
- International Journal of Mechanical Engineering Education (http://journals.mup.manchester.ac.uk/cgi-bin/MUP?COMval=journal&key=IJMEE)
- Journal of Science Education and Technology
- Journal of STEM Education
- Journal of Women and Minorities in Science and Engineering (http://www.begellhouse.com/journals/00551c876cc2f027.html)
- Research in Engineering Design (http://www.cs.cmu.edu/~sfinger/red/red.html)
- Technology and Children (http://www.iteaconnect.org/Publications/t&c.htm)
- Technology Teacher (http://www.iteaconnect.org/Publications/ttp.htm)
- Transactions on Engineering Education

*Source: Noemi Mendoza-Diaz & James Cawthorne, School of Engineering Education, Purdue University, 9 December 2008
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 Teaching and Learning Centers** — Australia: UICEE, UNESCO International Centre for Engineering Education; Denmark: UCPBLEE, UNESCO Chair in Problem Based Learning in Engineering Education; 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.

**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

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
- **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/

New! (Started 2007)
Thank you!

Mérida—Yucatán, México • June 19, 2009

mfc@purdue.edu   rdelcarm@purdue.edu