

A Workshop on  
**Building Capability and Communities  
in Engineering Education Research**

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Mérida—Yucatán, México • June 19, 2009



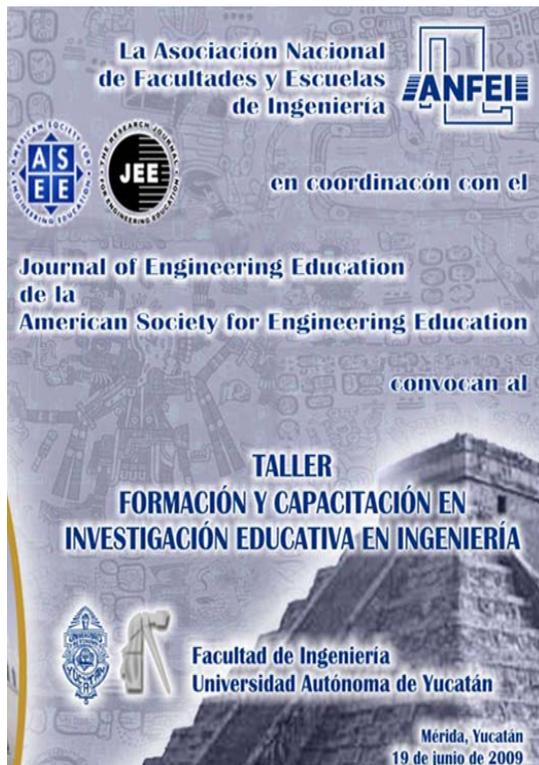
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# Overview

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

# 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

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**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.

# Informal vs. Formal Research

Example Topic: Learning about the 2<sup>nd</sup> Law of Thermodynamics

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

# Informal vs. Formal Research

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

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

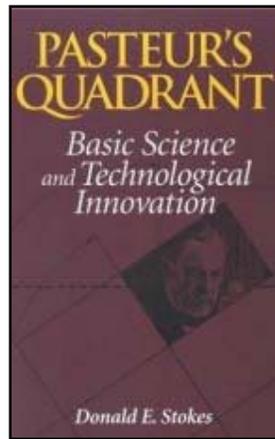
## Research

(appropriate design and methodology)

## Practice

(implications for teaching)

# Research can be inspired by ...



**Understanding  
(Basic)**

		<b>Use (Applied)</b>	
		<b>No</b>	<b>Yes</b>
<b>Yes</b>	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)	
<b>No</b>		Pure applied research (Edison)	

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

# RREE2

- **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.

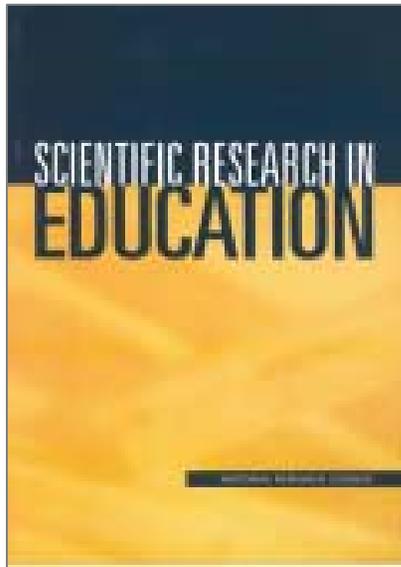


# What does education research look like?

- (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**

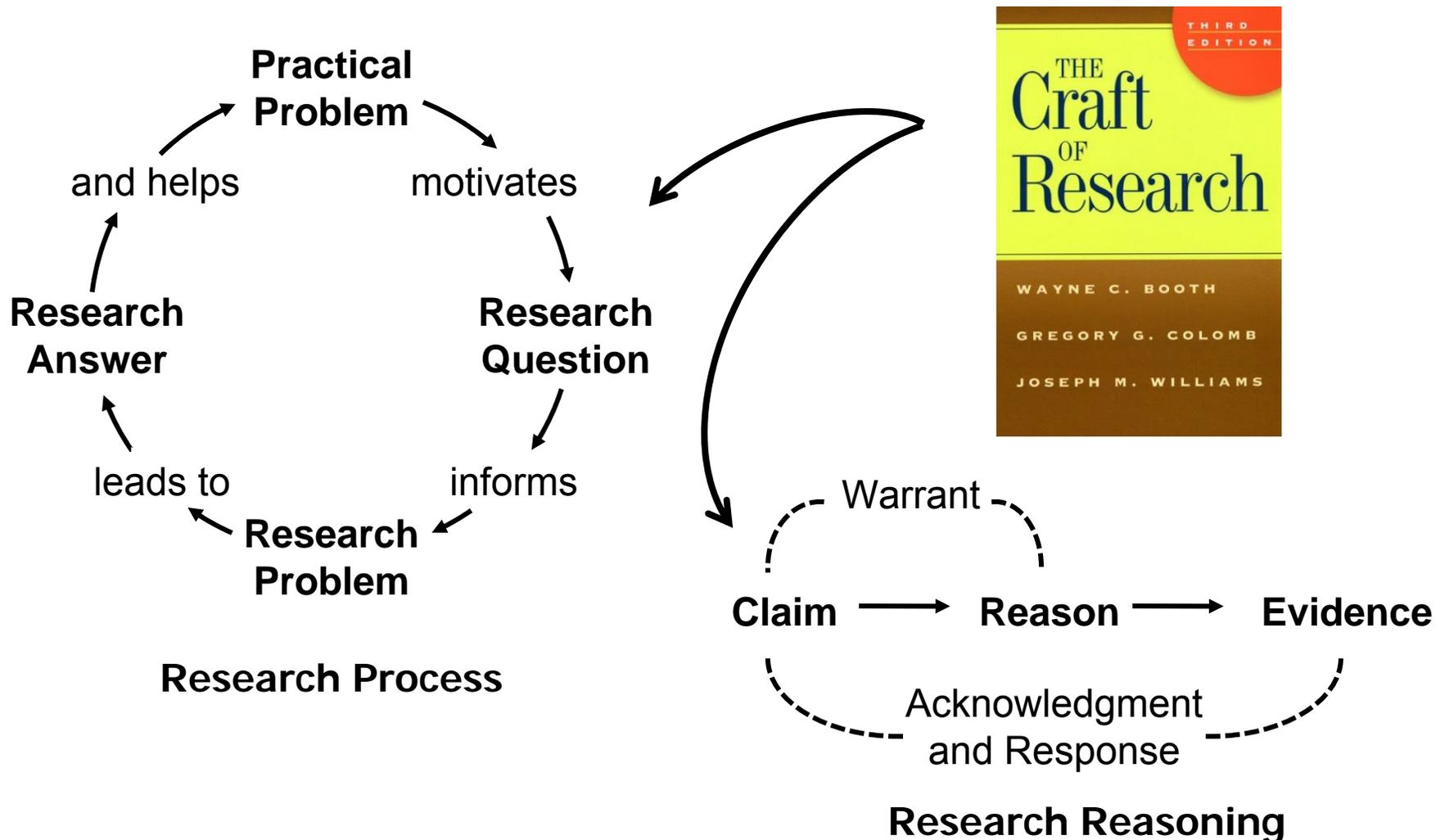


- How do our lists compare with the NRC six?



- Is a global list possible? Do cultural contexts matter?

# The research process and reasoning



## **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 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 motivation

- Behavior theory
- Cognitive: Self-efficacy
- Cognitive: Task value
- Cognitive: Self-determination
- Cognitive: Goal orientation

## 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

# 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.

# 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.

## **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](#)



[www.asee.org/jee](http://www.asee.org/jee)

**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.reeonline.org](http://www.reeonline.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/ijstol/>)
- **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/1st/jls/>)
- **Journal of Engineering Education** (<http://www.asee.org/jee>)
- **Journal of Higher Education** (<http://www.jstor.org/journals/00221546.html>)
- **Journal of Research in Science Teaching**  
(<http://www3.interscience.wiley.com/cgi-bin/jhome/31817?CRETRY=1&SRETRY=0>)
- **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/](http://www.press.jhu.edu/journals/review_of_higher_education/))
- **Sociology of Education** ([http://www.asanet.org/cs/root/leftnav/publications/journals/sociology\\_of\\_education/homepage](http://www.asanet.org/cs/root/leftnav/publications/journals/sociology_of_education/homepage))
- **Science & Education**
- **Students in Transition**

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\*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)

- **Australasian Journal of Engineering Education** (<http://www.aeee.com.au/journal/>)
- **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>)
- **Global Journal of Engineering Education** (<http://www.eng.monash.edu.au/uicee/gjee/>)
- **IEEE Engineering Science and Education Journal** (<http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=2222>)
- **IEEE Transactions on Education**
- **International Journal of Electrical Engineering Education** (<http://journals.mup.man.ac.uk/cgi-bin/MUP?COMval=journal&key=IJEEE>)
- **International Journal of Continuing Engineering Education and Life-Long Learning** (<http://www.inderscience.com/browse/index.php?journalID=6&year=2008&vol=18&issue=1>)
- **International Journal of Engineering Education**
- **International Journal of Mechanical Engineering Education** (<http://journals.mup.man.ac.uk/cgi-bin/MUP?COMval=journal&key=IJMEE>)
- **Journal of Professional Issues in Engineering Education and Practice** (<http://scitation.aip.org/epo>)
- **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/ttt.htm>)
- **Transactions on Engineering Education**



Other  
journals in  
Mexico?  
Latin  
America?

## **Objective 4**

**Become aware of global  
communities and their networks**

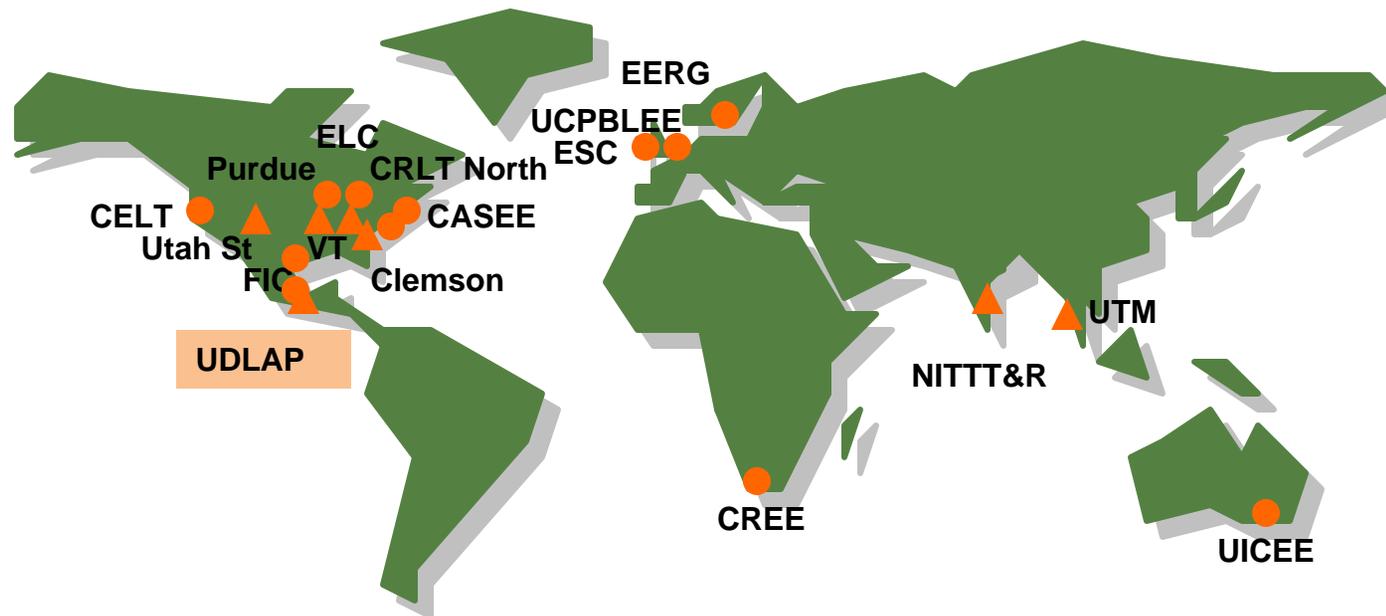
# An emerging global community



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

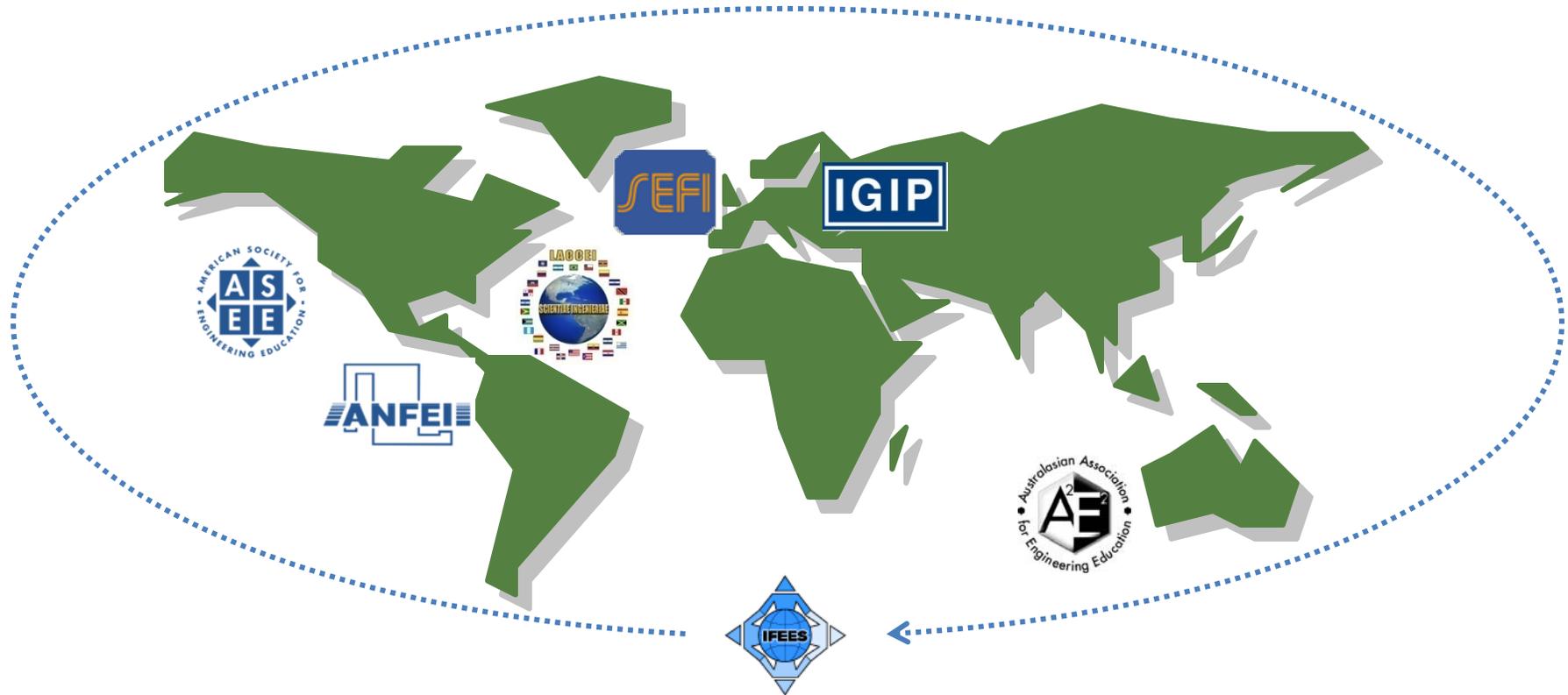
What follows is a **sample** — it is NOT an exhaustive list!

# 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 Américas, Puebla

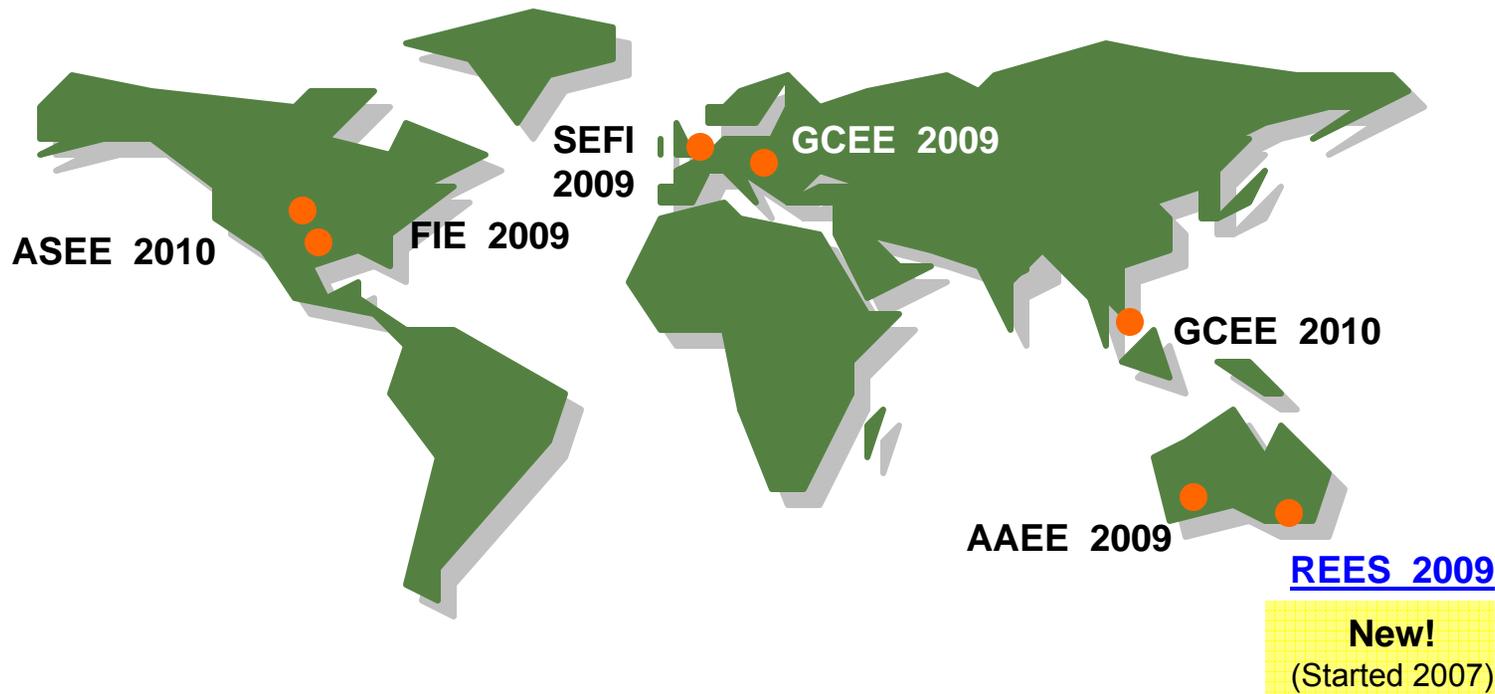
# Engineering education societies...



**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

# Forums for dissemination...



## Conferences with engineering education research presentations:

- **ASEE** — Annual Conference, American Society for Engineering Education, see [www.asee.org](http://www.asee.org)
- **AAEE** — Annual Conference, Australasian Association for Engineering Education, see [www.aee.com.au](http://www.aee.com.au)
- **FIE** — Frontiers in Education, sponsored by ERM/ASEE, IEEE Education Society and Computer Society, [/fie-conference.org/erm](http://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](http://www.asee.org)
- **SEFI** — Annual Conference, Société Européenne pour la Formation des Ingénieurs , see [www.sefi.be](http://www.sefi.be)
- **REES** — Research on Engineering Education Symposium, [rees2009.pbwiki.com/](http://rees2009.pbwiki.com/)

# Thank you!

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