Fundamentals of Engineering Education Research

Rigorous Research in Engineering Education Initiative
(NSF DUE 0817461)
CLEERhub.org

HKUST Summer Workshop on Engineering Education Innovation – 29 June, 2012

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University of Minnesota

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

Engineering Education: Advancing the Practice
Karl A. Smith

Research
•Process Metallurgy 1970 -1992
•Learning ~1974
•Design ~1995
•Engineering Education Research & Innovation ~ 2000

Innovation – Cooperative Learning
•Need identified ~1974
•Introduced ~1976
•FIE conference 1981
•*JEE* paper 1981
•Research book 1991
•Practice handbook 1991
•*Change* paper 1998
•*Teamwork and project management* 2000
•*JEE* paper 2005

National Academy of Engineering - Frontiers of Engineering Education Symposium - December 13-16, 2010 - Slides PDF [Smith-NAE-FOEE-HPL-UbD-12-10-v8.pdf]

Process Metallurgy

- Dissolution Kinetics – liquid-solid interface
- Iron Ore Desliming – solid-solid interface
- Metal-oxide reduction roasting – gas-solid interface

Dissolution Kinetics

- Theory – Governing Equation for Mass Transport
- Research – rotating disk
- Practice – leaching of silver bearing metallic copper

$$(\nabla c \bullet \underline{v}) = D\nabla^2 c$$

$$v_y \frac{dc}{dy} = D \frac{d^2 c}{dy^2}$$

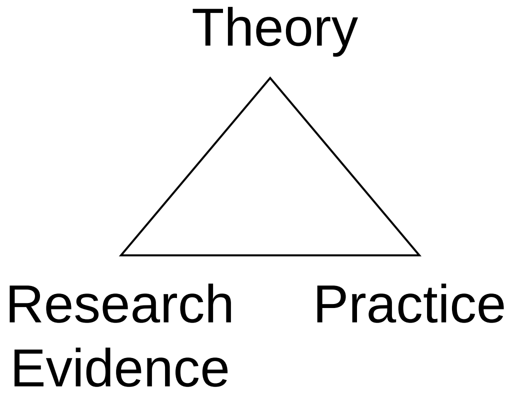
First Teaching Experience

- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics

Lila M. Smith

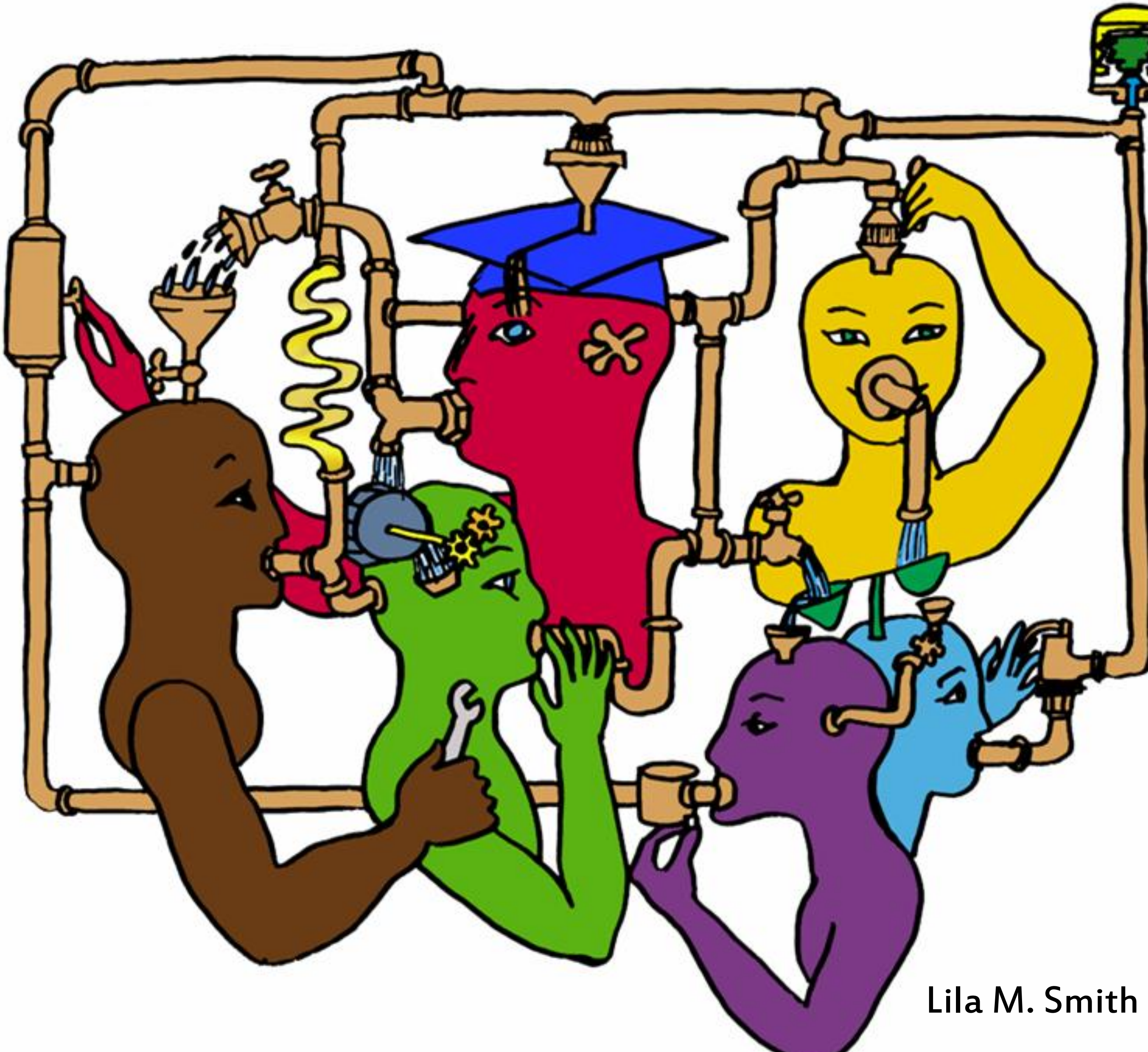
Engineering Education

- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics
- Research – ?
- Theory – ?



University of Minnesota College of Education Social, Psychological and Philosophical Foundations of Education

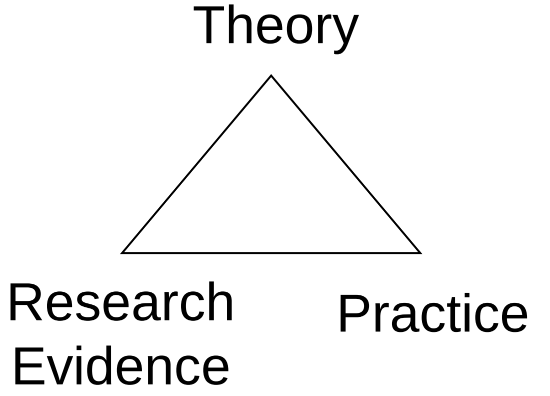
- Statistics, Measurement, Research Methodology
- Assessment and Evaluation
- Learning and Cognitive Psychology
- Knowledge Acquisition, Artificial Intelligence, Expert Systems
- Social psychology of learning – student – student interaction

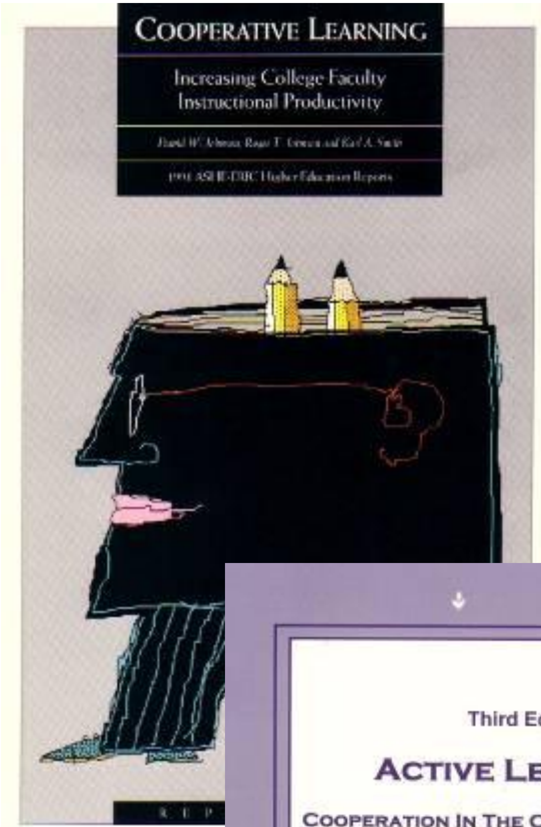


Lila M. Smith

Cooperative Learning

- Theory – Social Interdependence – Lewin – Deutsch – Johnson & Johnson
- Research – Randomized Design Field Experiments
- Practice – Formal Teams/Professor's Role





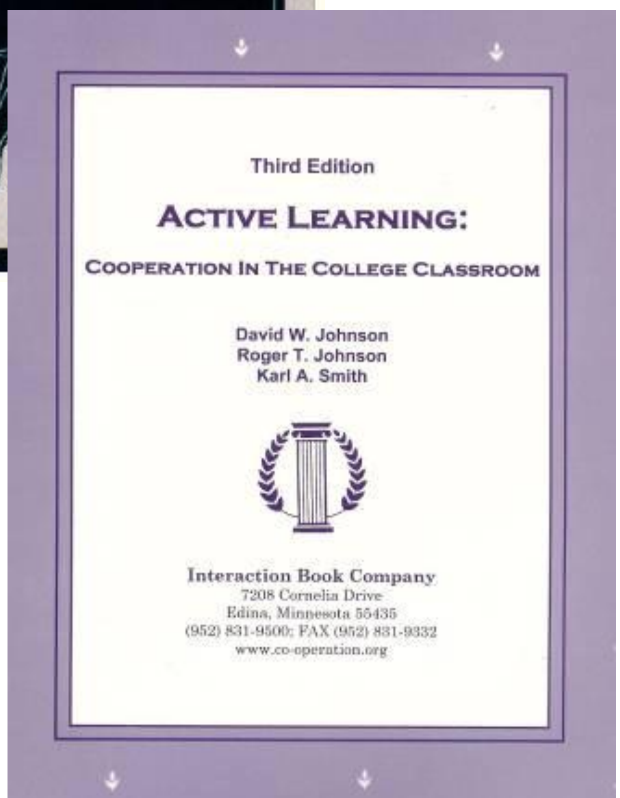
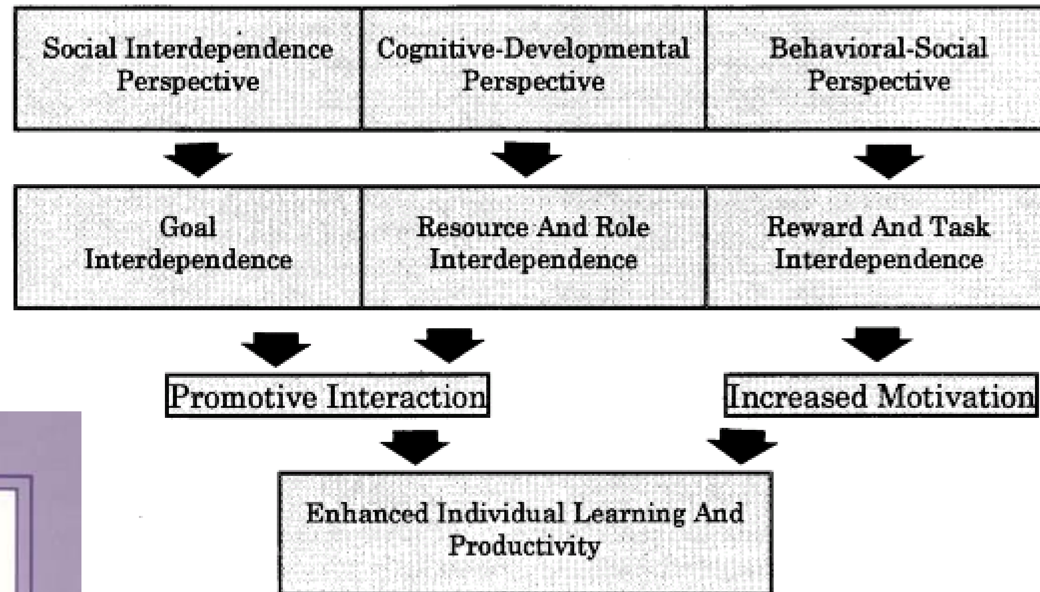


Figure A.1 A General Theoretical Framework



Cooperative Learning

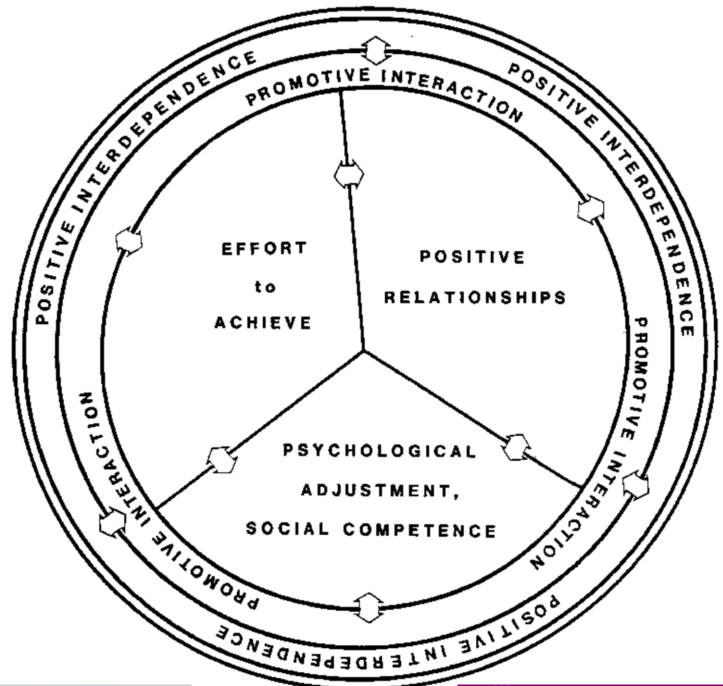
- •Positive Interdependence
- •Individual and Group Accountability
- •Face-to-Face Promotive Interaction
- •Teamwork Skills
- •Group Processing

[*First edition 1991]

Cooperative Learning Research Support

Johnson, D.W., Johnson, R.T., & Smith, K.A. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change*, *30* (4), 26-35.

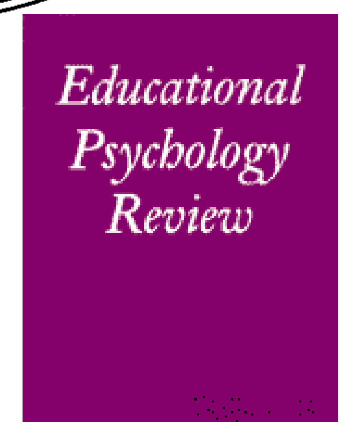
- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes



Outcomes

1. Achievement and retention
2. Critical thinking and higher-level reasoning
3. Differentiated views of others
4. Accurate understanding of others' perspectives
5. Liking for classmates and teacher
6. Liking for subject areas
7. Teamwork skills

January 2005



March 2007

PBL@UD

Institute for Transforming Undergraduate Education

Problem-Based Learning at University of Delaware

The Motivation to Learn Begins with a Problem

In a problem-based learning (PBL) model, students engage complex, challenging problems and collaboratively work toward their resolution. PBL is about students connecting disciplinary knowledge to real-world problems—the motivation to solve a problem becomes the motivation to learn.

PBL@UD

For more than ten years, the Leaders and Fellows of the Institute for Transforming Undergraduate Education (ITUE) have encouraged the adoption of student-centered and active classroom pedagogies—and in particular—the use of PBL in the undergraduate classroom. On- and off-campus workshops are held for faculty and students to enhance their understanding of PBL.

Recipient of a Hesburgh Certificate of Excellence

The Theodore M. Hesburgh Award was created to acknowledge and reward successful, innovative faculty development programs that enhance undergraduate teaching. ITUE is a recipient of the Hesburgh Certificate of Excellence for its work in implementing problem-based learning in the classroom.

What we offer

PBL Clearinghouse

Find great problems for your

In this peer-reviewed online resource, educators have the opportunity to submit and publish their own problems and articles on problem-based learning.

Learn more

PBL Training at a lower cost: Attend our January 4-6 Workshop for an Introduction to PBL!

This workshop will demonstrate problem-based learning (PBL) and model ways that PBL can be used effectively in all disciplines. We will begin with a problem, and participants will work in teams to experience first hand what this instructional approach entails. We will then move to the main focus of this program: writing effective problem-based materials. Participants will leave the session with new or revised problems for use in their courses.

Learn more

http://www.udel.edu/inst/

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About the SCALE-UP Project...

This research was supported, in part, by the U.S. Department of Education's Fund for the Improvement of Post-Secondary Education (FIPSE), the National Science Foundation, Hewlett-Packard, Apple Computer, and Pasco Scientific. Opinions expressed are those of the authors and not necessarily those of our sponsors.

The primary goal of the Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project is to establish a highly collaborative, hands-on, computer-rich, interactive learning environment for large-enrollment courses.

Educational research indicates that students should collaborate on interesting tasks and be deeply involved with the material they are studying. We promote active learning in a redesigned classroom of 100 students or more. (Of course, smaller classes can also benefit.) We believe the SCALE-UP Project has the potential to radically change the way large classes are taught at colleges and universities. The social interactions between students and with their teachers appears to be the "active ingredient" that make the approach work. As more and more instruction is handled virtually via technology, the relationship-building capability of brick and mortar institutions becomes even more important. The pedagogical methods and classroom management techniques we design and disseminate are general enough to be used in a wide variety of classes at many different types of colleges.

Classtime is spent primarily on "tangibles" and "ponderables ". Essentially these are hands-on activities, simulations, or interesting questions and problems. There are also some hypothesis-driven labs where students have to write detailed reports. (This example is more sophisticated than most, but shows what the best students are capable of doing.) Students sit in three groups of three students at 6 or 7 foot diameter round tables. Instructors circulate and work with teams and individuals, engaging them in Socratic-like dialogues. Each table has at least three networked laptops. The setting is very much like a banquet hall, with lively interactions nearly all the time. Many other colleges and universities are adopting/adapting the SCALE-UP room design and pedagogy. Engineering schools are especially pleased with the course objectives, which fit in well with the requirements for ABET accreditation.

Materials developed for the course were incorporated into what became the leading introductory physics textbook, used by more than 1/3 of all science, math, and engineering students in the country.

Impact

Rigorous evaluations of learning have been conducted in parallel with the curriculum development effort. Besides hundreds of hours of classroom video and audio recordings, we also have conducted numerous interviews and focus groups, conducted many conceptual learning assessments (using nationally-recognized instruments in a pretest/posttest protocol), and collected portfolios of student work. We have data comparing nearly 16,000 traditional and SCALE-UP students. Our findings can be summarized as the following:

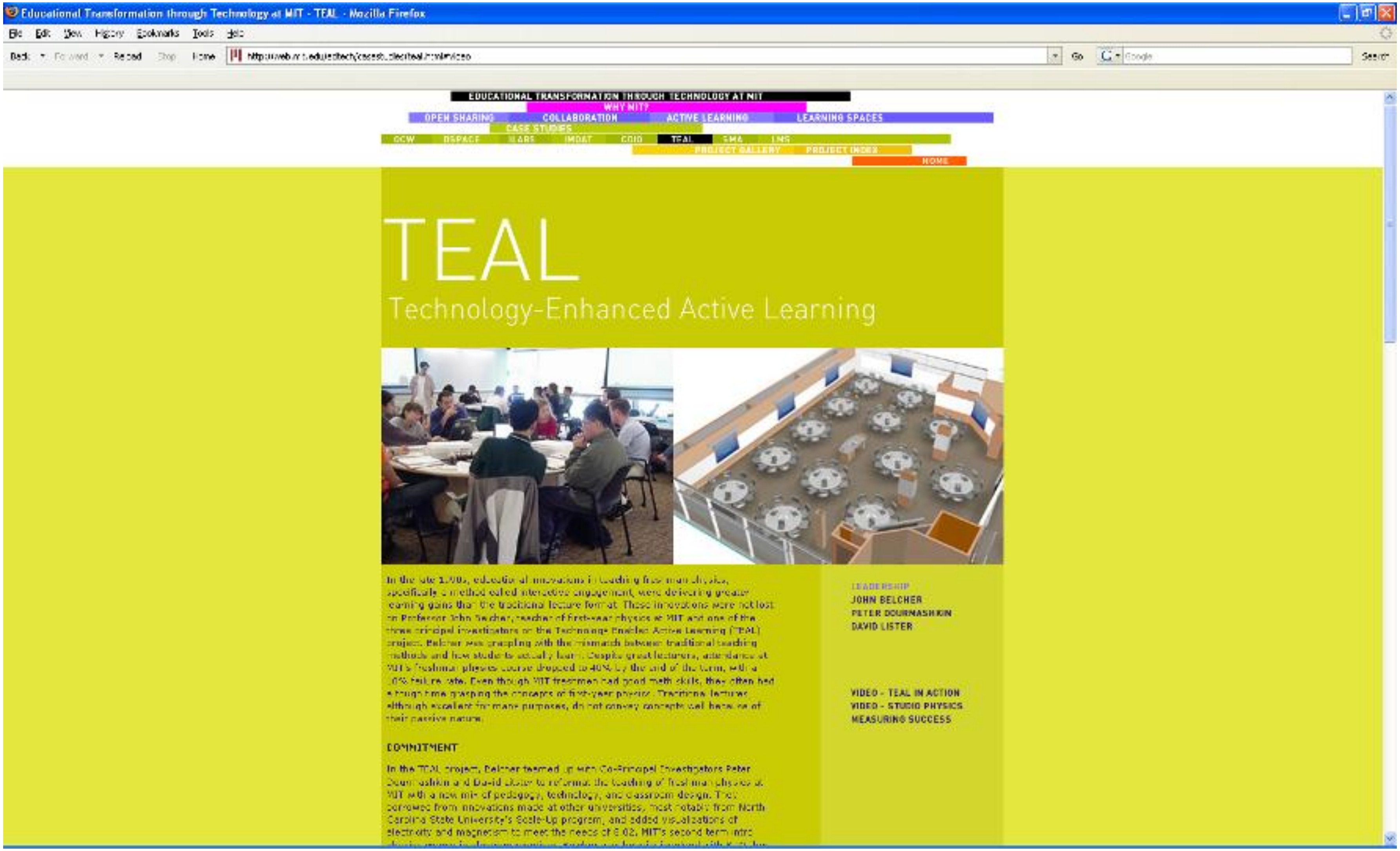
- Ability to solve problems is improved
- Conceptual understanding is increased
- Attitudes are improved
- Failure rates are drastically reduced, especially for women and minorities
- "At risk" students do better in later engineering statics classes

Details

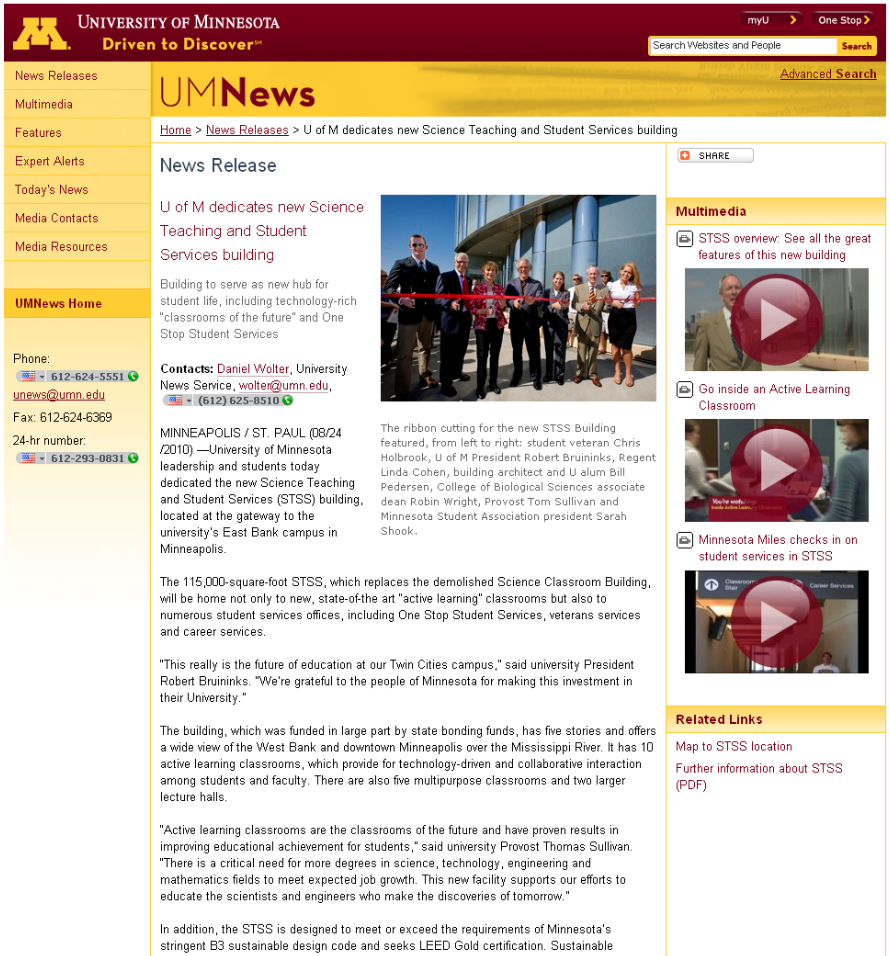
A chapter describing the approach and its underpinnings is available. A shorter description is posted on the PKAL website, or you can view an article describing the project from the proceedings of the Sigma Xi Forum on Reforming Undergraduate Education. The Raleigh *News & Observer* newspaper also has a description of the project. The very successful pilot project was described in the first issue of the Physics Education Research supplement to Am. J. of Physics. See our publication page for more information.

More than 50 colleges and universities across the US have adapted the SCALE-UP approach to their own institutions. In all cases, the basic idea remains the same: get the students working together to examine something interesting. That frees the instructor to roam about the room, asking questions and stirring up debates. Classes in physics, chemistry, math, engineering, and even literature have been taught this way. If you want more information, please contact Dr. Robert Beichner.

http://www.ncsu.edu/PER/scaleup.html



http://web.mit.edu/edtech/casestudies/teal.html#video



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News Release

U of M dedicates new Science Teaching and Student Services building

Building to serve as new hub for student life, including technology-rich "classrooms of the future" and One Stop Student Services

Contacts: Daniel Wolter, University News Service, wolter@umn.edu, (612) 625-8510

The ribbon cutting for the new STSS Building featured, from left to right: student veteran Chris Holbrook, U of M President Robert Bruininks, Regent Linda Cohen, building architect and U alum Bill Pedersen, College of Biological Sciences associate dean Robin Wright, Provost Tom Sullivan and Minnesota Student Association president Sarah Shook.

MINNEAPOLIS / ST. PAUL (08/24/2010) —University of Minnesota leadership and students today dedicated the new Science Teaching and Student Services (STSS) building, located at the gateway to the university's East Bank campus in Minneapolis.

The 115,000-square-foot STSS, which replaces the demolished Science Classroom Building, will be home not only to new, state-of-the art "active learning" classrooms but also to numerous student services offices, including One Stop Student Services, veterans services and career services.

"This really is the future of education at our Twin Cities campus," said university President Robert Bruininks. "We're grateful to the people of Minnesota for making this investment in their University."

The building, which was funded in large part by state bonding funds, has five stories and offers a wide view of the West Bank and downtown Minneapolis over the Mississippi River. It has 10 active learning classrooms, which provide for technology-driven and collaborative interaction among students and faculty. There are also five multipurpose classrooms and two larger lecture halls.

"Active learning classrooms are the classrooms of the future and have proven results in improving educational achievement for students," said university Provost Thomas Sullivan. "There is a critical need for more degrees in science, technology, engineering and mathematics fields to meet expected job growth. This new facility supports our efforts to educate the scientists and engineers who make the discoveries of tomorrow."

In addition, the STSS is designed to meet or exceed the requirements of Minnesota's stringent B3 sustainable design code and seeks LEED Gold certification. Sustainable

SHARE

Multimedia

STSS overview: See all the great features of this new building

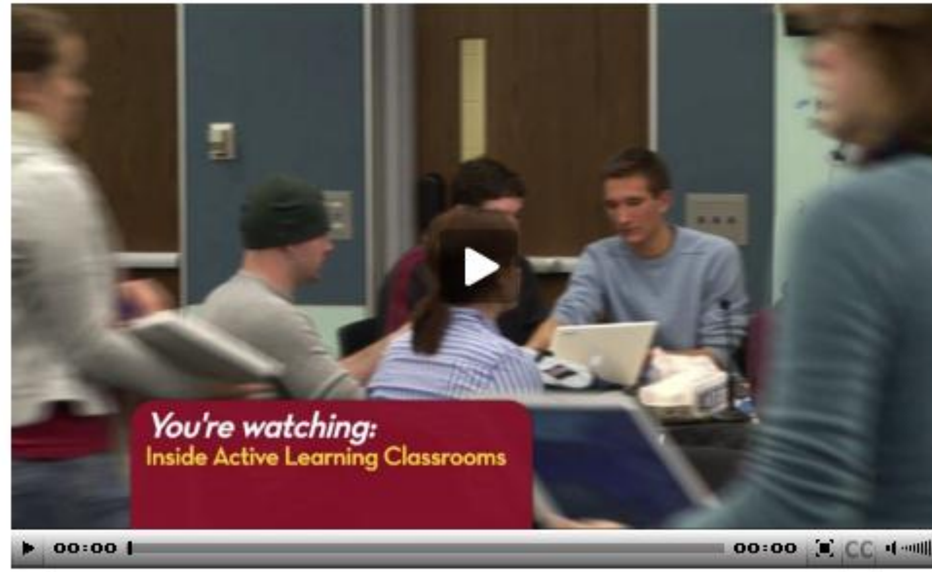
Go inside an Active Learning Classroom

Minnesota Miles checks in on student services in STSS

Related Links

Map to STSS location

Further information about STSS (PDF)



http://mediamill.cla.umn.edu/mediamill/embed/78755

http://www1.umn.edu/news/news-releases/2010/UR_CONTENT_248261.html

http://www.youtube.com/watch?v=lfT_hoiuY8w

http://youtu.be/lfT_hoiuY8w

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?**

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.

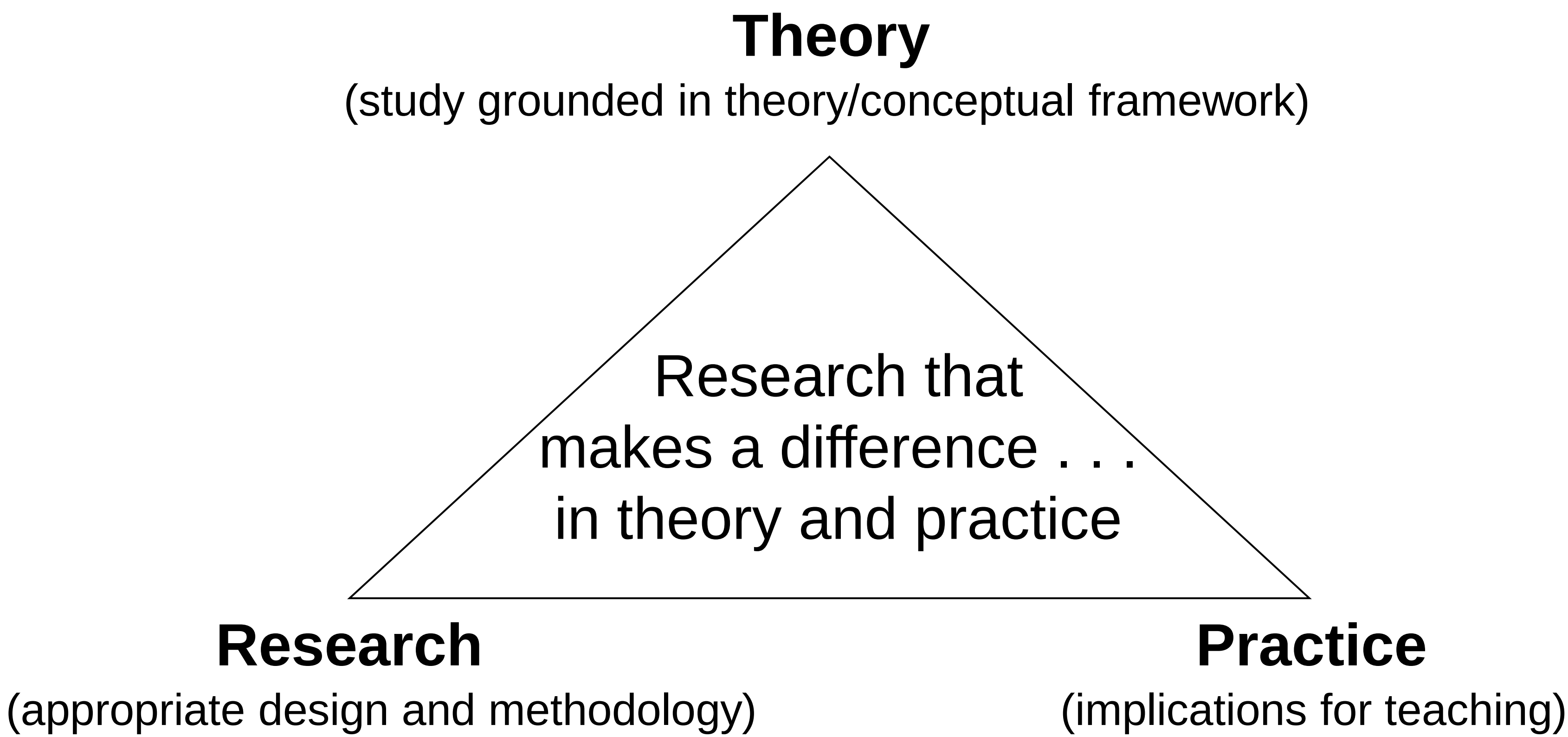
Workshop Intentions / Participant Learning Outcomes

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



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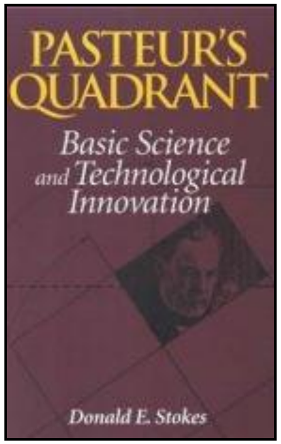
http://inside.mines.edu/research/cee/ND.htm

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.

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 CLEERhub.org

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

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.

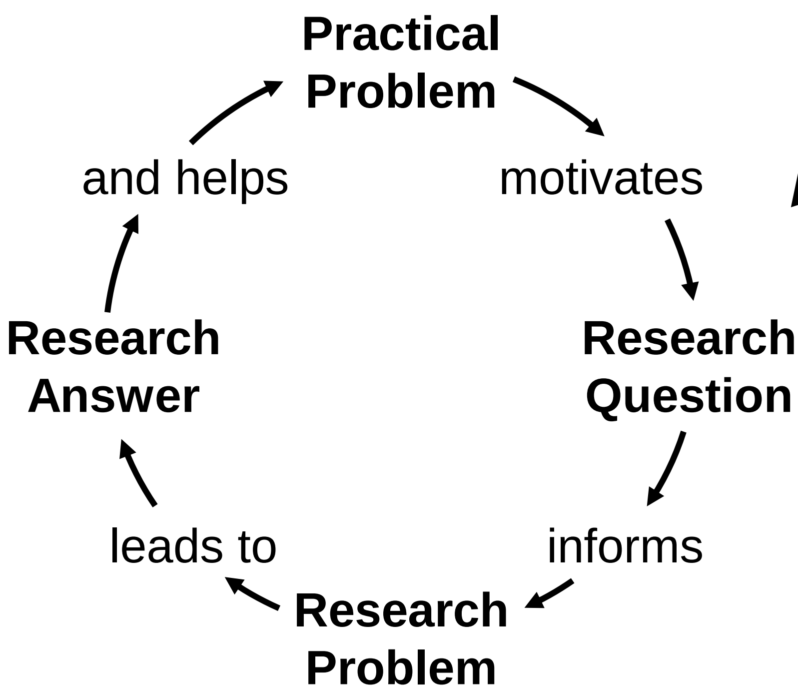
Guiding principles for scientific research in education

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**

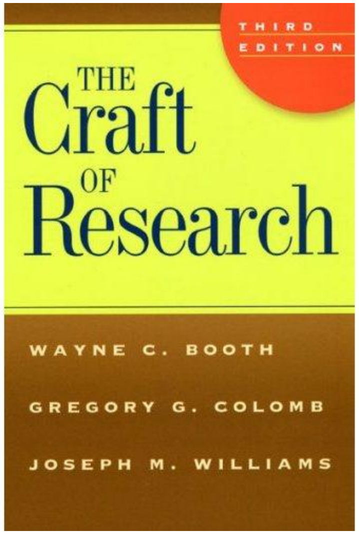
- **How do our lists compare with the NRC six?**
- **Is a global list possible? Do cultural contexts matter?**

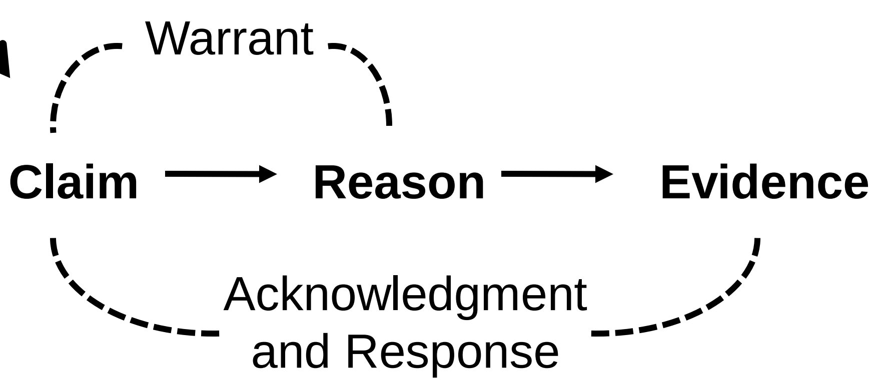
Source: Scientific Research in Education, National Research Council, 2002

The research process and reasoning



Research Process





Research Reasoning

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. http://cleerhub.org/resources/gb-svinicki

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.

Books, journals, online resources

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

What is your experience?

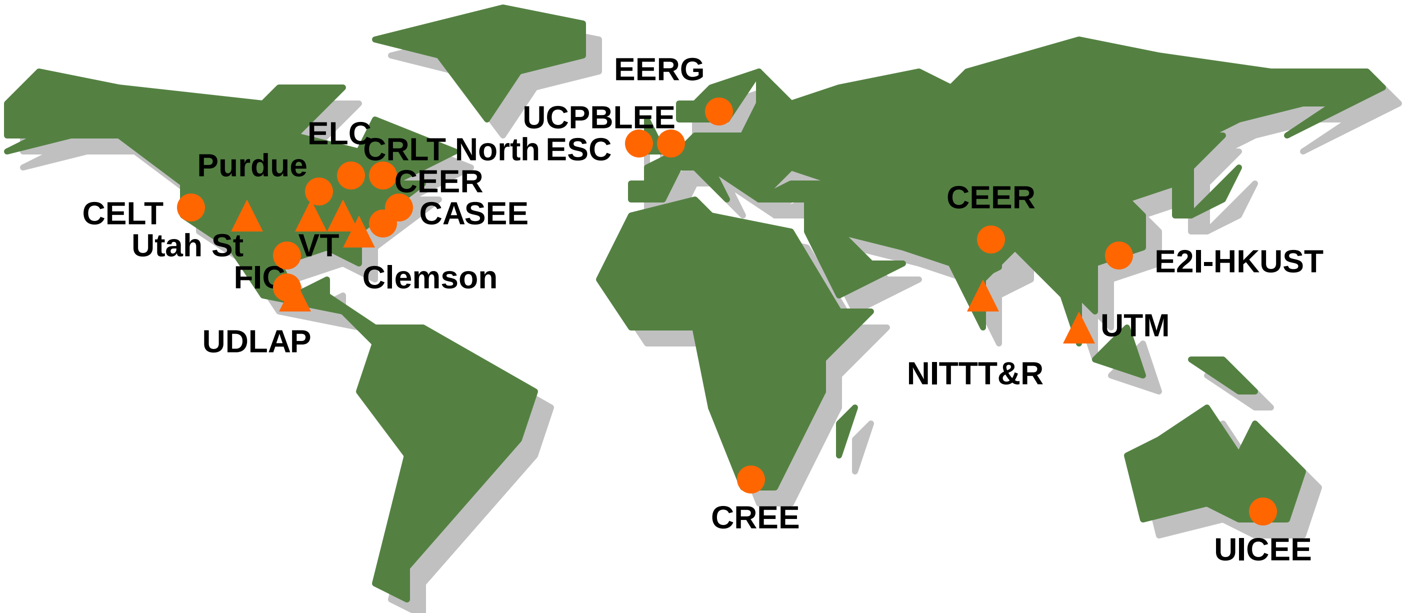
- Silently reflect on your experience with engineering education research
- Jot down
  - What has been the most exciting opportunity for you in this area?
  - What has been the most difficult challenge you have faced?
- Share with the person next to you

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

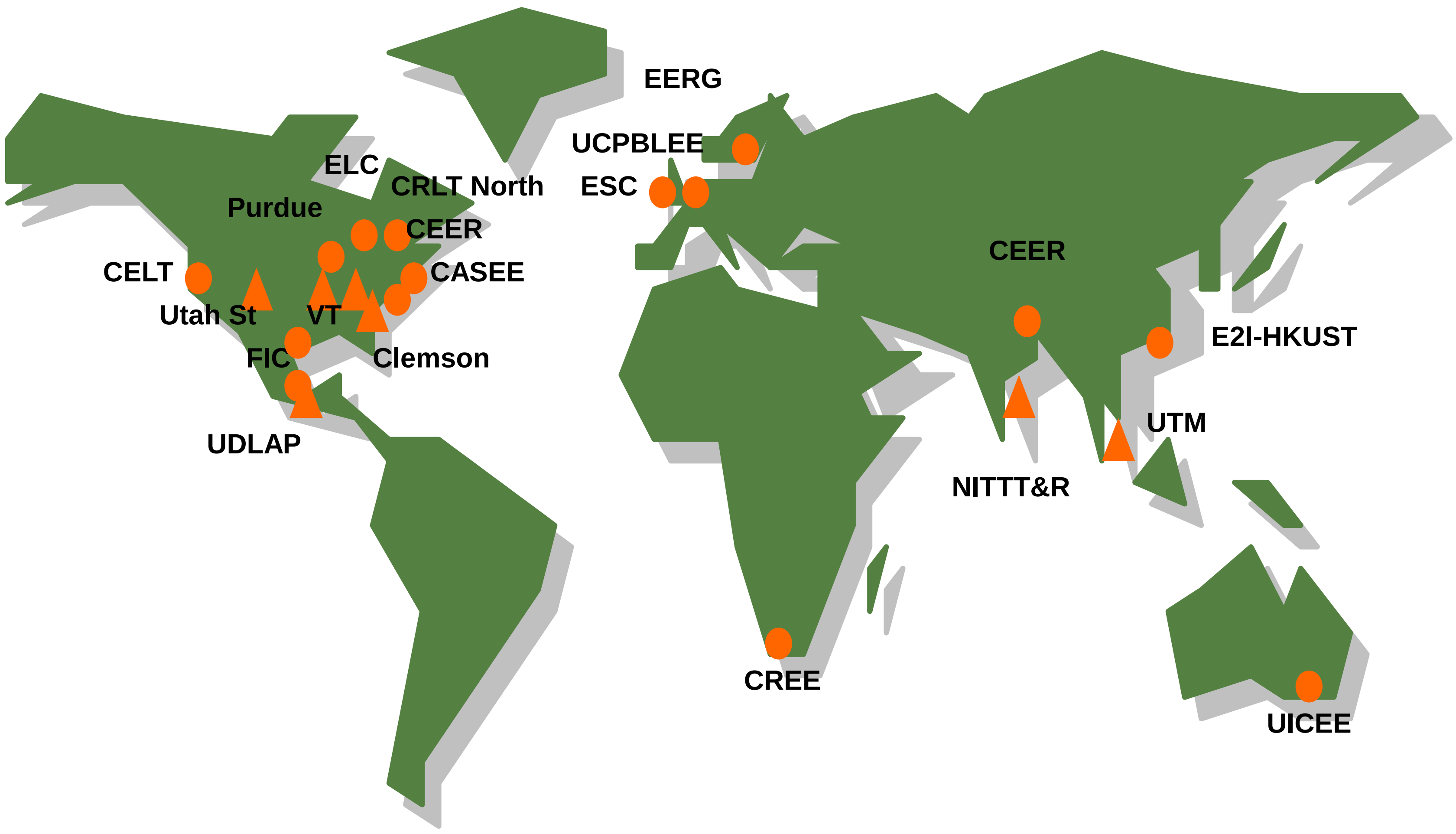
Groups, centers, departments…



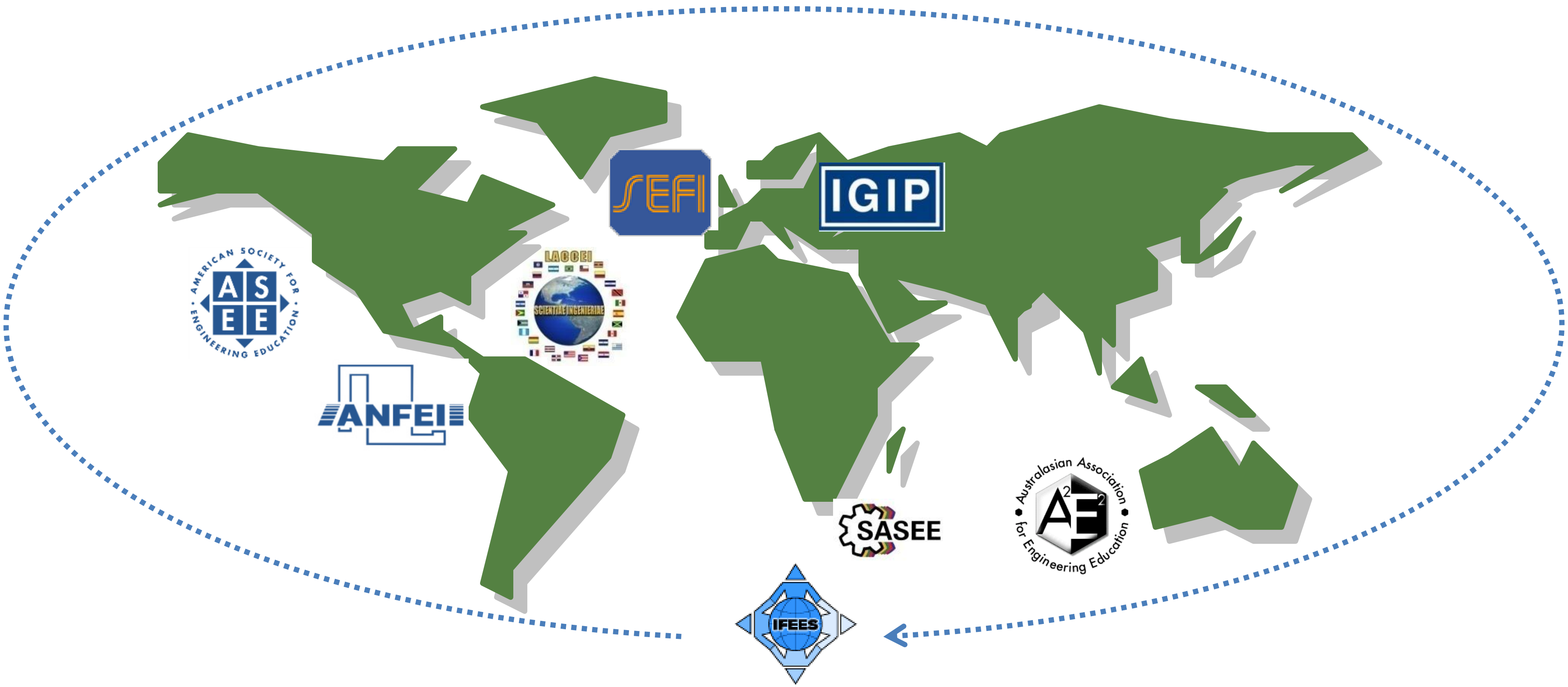
- **Engineering Education Centers** — Australia: UICEE, UNESCO International Centre for Engineering Education; Denmark: UCPBLEE, UNESCO Chair in Problem Based Learning in Engineering Education; Hong Kong: E2I, Engineering Education Innovation Center, Hong Kong University of Science and Technology; Pakistan: 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.

- **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

Groups, centers, departments…



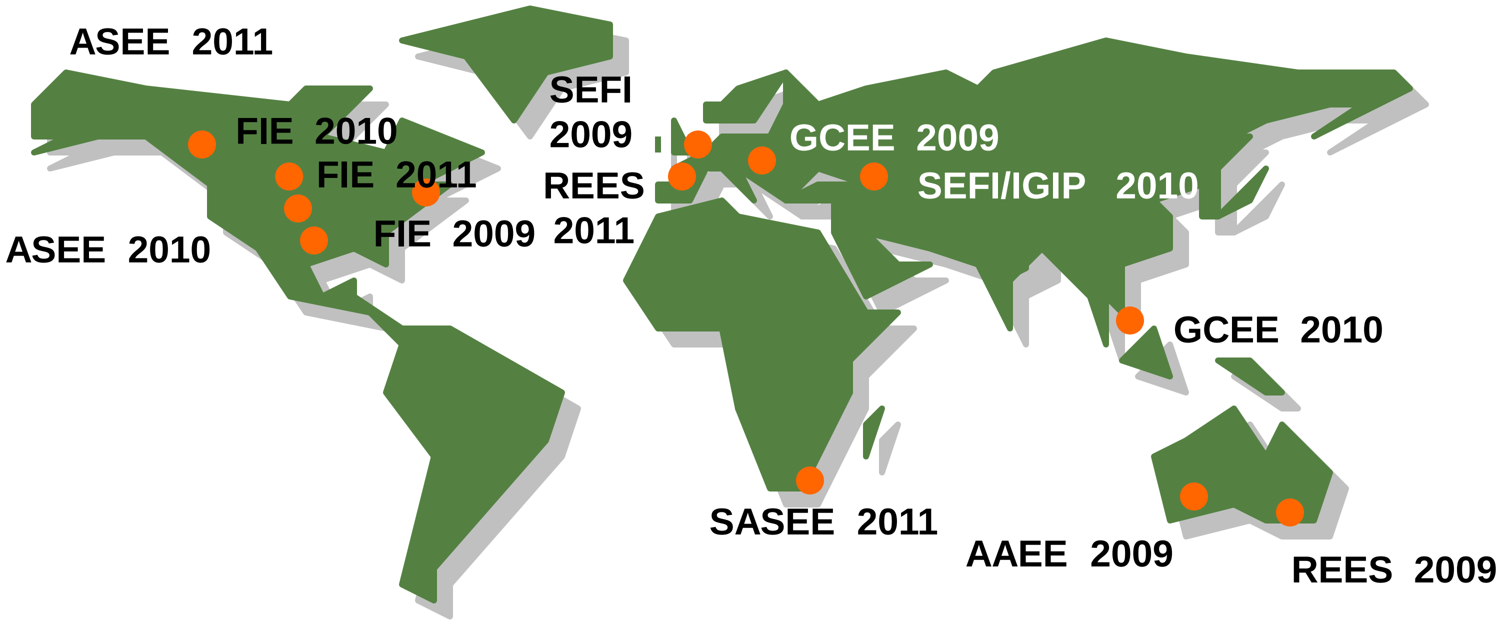
Engineering education societies…



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,

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

Engineering Education Research Networking Session

Connecting and Expanding the Engineering Education Research (EER) and Engineering Education Innovation (EEI) Communities

ASEE Headquarters Session T106D in partnership with the
Rigorous Research in Engineering Education Initiative
(DUE 0817461)
http://CLEERhub.org

ASEE Annual Conference – June 12, 2012 – T106D – 7:00 am – 8:30 am

Facilitated By

Karl A. Smith
Purdue University and
University of Minnesota

Ruth A. Streveler
Purdue University

Slides posted - http://www.ce.umn.edu/~smith/links.html

Activity	Time Allotted
Introduction of session and facilitators	5
Brief report on status of EER & EEI	
Update on RREE – CLEERHub.org (Collaboratory for Engineering Education Research)	10
Update on EER – NRC DBER report	5
Update on EEI – ASEE Innovation with Impact & NAE FOEE	10
Participant Networking	
Rapid introductions around guided questions – Four to five conversations in groups of 3 – as a way to meet many people	25
Identification of “intellectual neighborhoods” around research and innovation questions and opportunities – individual reflection and writing	5
Brainstorming on strategies to connect, expand, and sustain the emerging EER and EEI communities	10
Summary of ideas for (1) local, (2) national – conferences, etc. and (3) virtual community	5
Individuals share reflections with the large group, facilitators sum up the session and participants complete feedback forms	10

RREE

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

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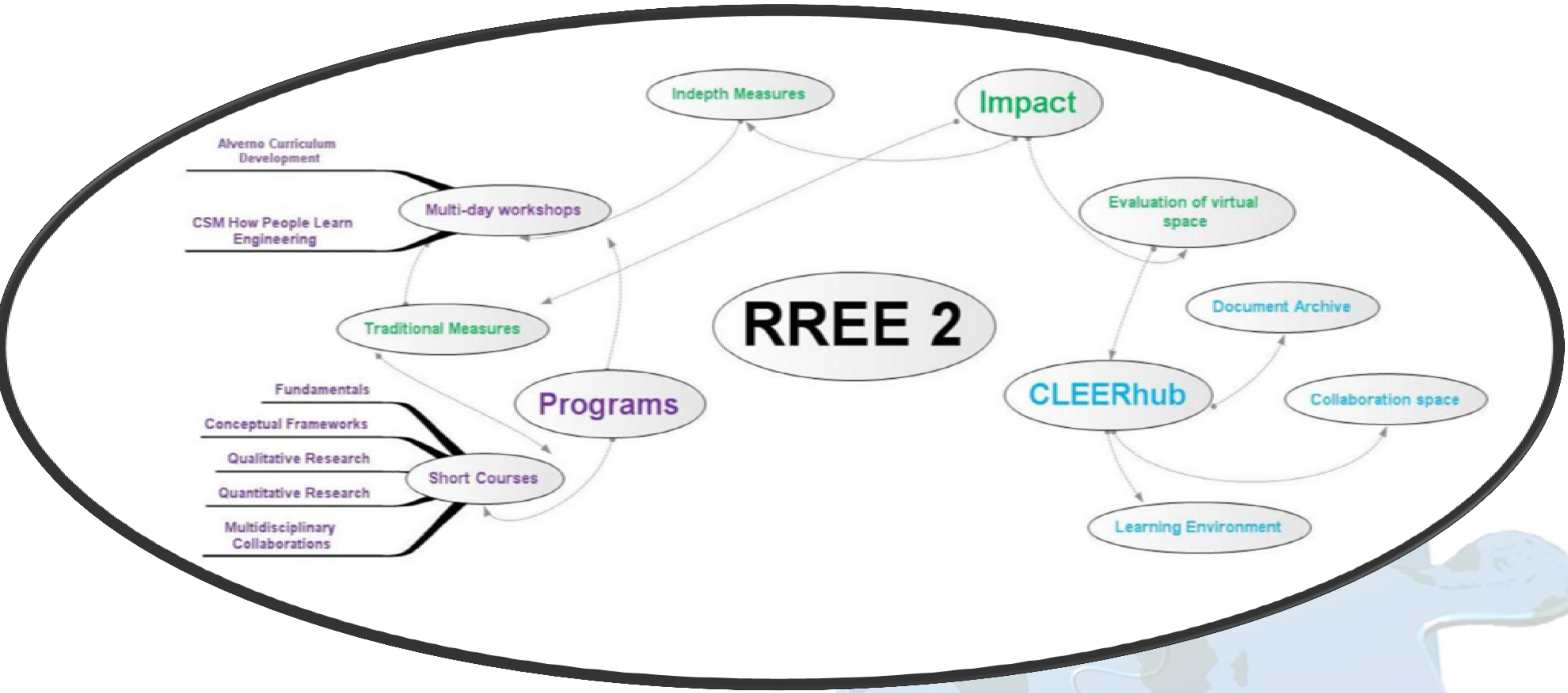
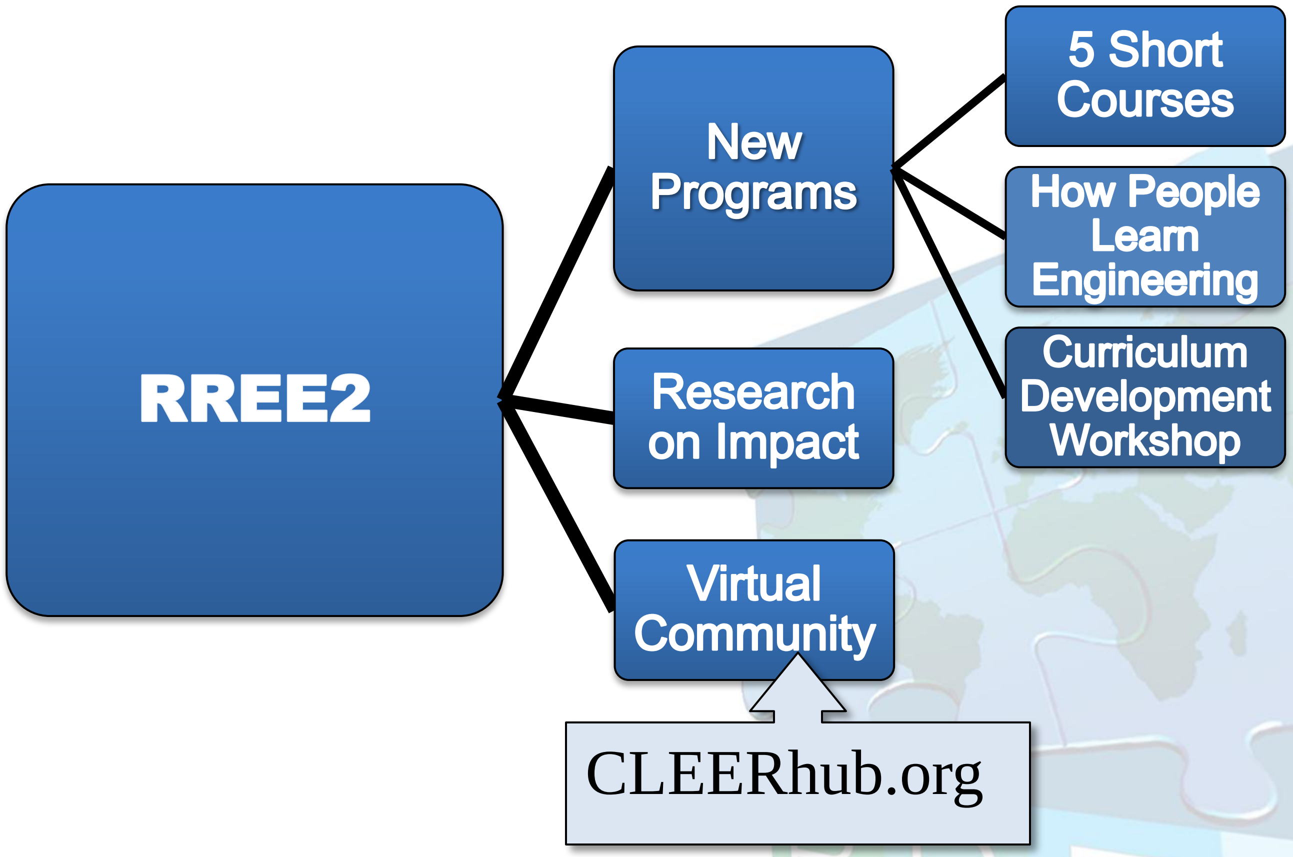
Collaborative partners: Purdue (lead), Alverno College, Colorado School of Mines, Howard University, Madison Area Technical College, National Academy of Engineering



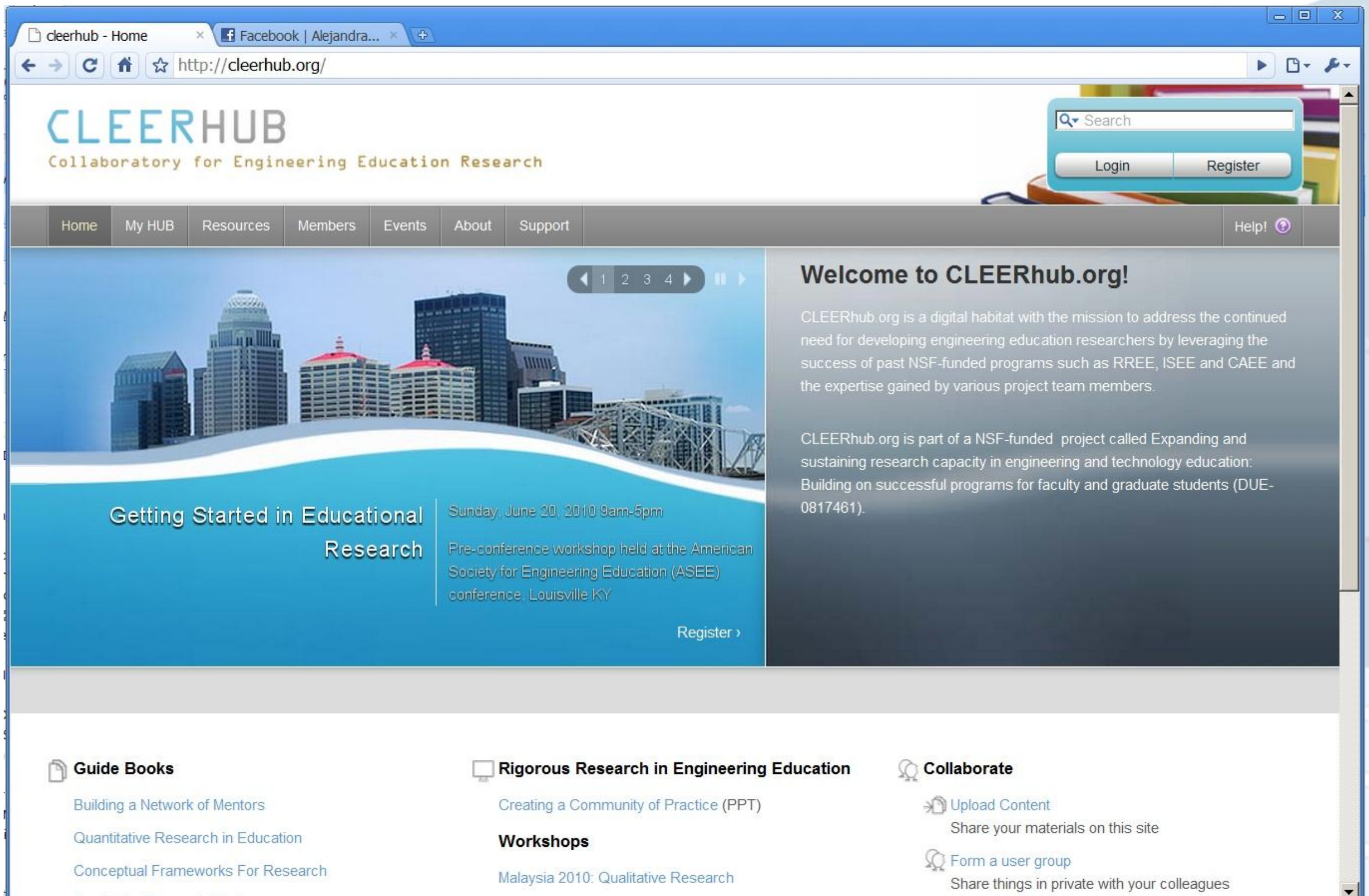
RIGOROUS RESEARCH *in* ENGINEERING EDUCATION



RIGOROUS RESEARCH *in* ENGINEERING EDUCATION

CLEERHUB

Collaboratory for Engineering Education Research



RREE

RIGOROUS RESEARCH *in* ENGINEERING EDUCATION

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

CLEERhub June 2012 Update

Objectives

- Explore available resources for your use.
- Share information about upcoming improvements.

RIGOROUS RESEARCH *in* ENGINEERING EDUCATION

CLEERhub's Vision & Mission

Vision:

- To be the leader in engineering education research content and collaborative opportunities.

Mission:

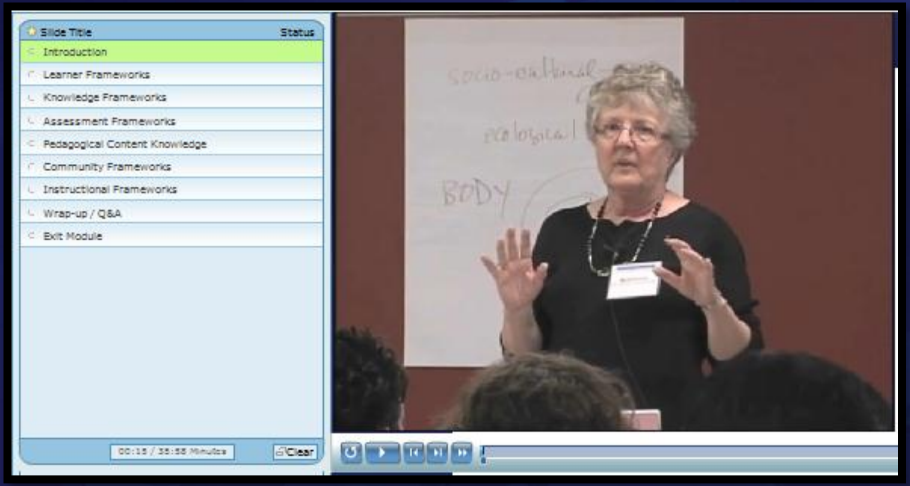
- Partnering with the community to develop engaging and useful content.
- Continually improving user experience with regards to information availability, platform ease of use, and tools that enable collaboration.

RIGOROUS RESEARCH in ENGINEERING EDUCATION

What's Available Now

Some of our most popular resources:

- Fundamentals of Engineering Education Research
- Qualitative and Quantitative Research Methods
- Exploring How People Learn Engineering



Example of a Learning Module.

RIGOROUS RESEARCH *in* ENGINEERING EDUCATION

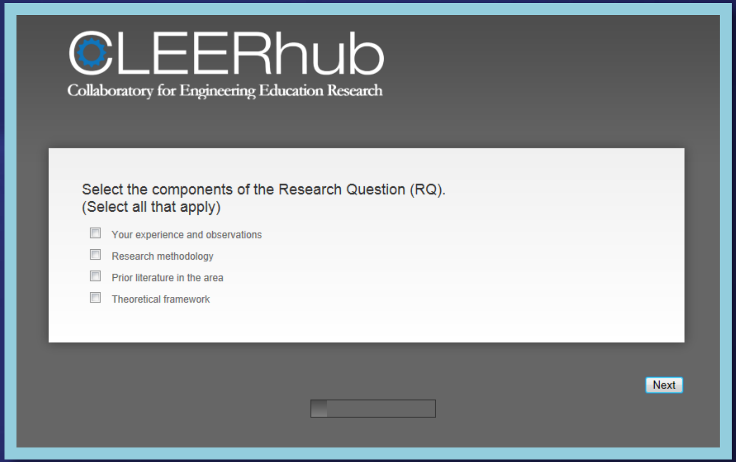
What's Coming Up

- Expanding accessibility by adopting the HTML 5 standard.
  - This enables users to access content via tablets and mobile devices.
- Self-scoring quizzes to help you gain insight into your understanding.

RIGOROUS RESEARCH *in* ENGINEERING EDUCATION

Self-Scoring Quizzes

- Many of our resources will have self-scoring quizzes to help you gain insight into your understanding.



I Want More Information!

Request more info from your mobile phone.

Or…

Complete the request for more information from a computer. We've shortened the URL to make it easier to write down.

http://bit.ly/Lj3zb6

RIGOROUS RESEARCH *in* ENGINEERING EDUCATION

Recent Reports/Initiatives

- National Research Council Discipline-Based Education Research (DBER)
  - http://www.nap.edu/catalog.php?record_id=13362
- ASEE Innovation with Impact report
  - http://www.asee.org/about-us/the-organization/advisory-committees/Innovation-with-Impact
- NAE Engineering Education Research and Innovation Activities
- Froyd, J.E., Wankat, P.C. & Smith, K.A. (2012). Five major shifts in 100 years of engineering education. *Proceedings of the IEEE*
  - http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=06185632

Discipline-Based Education Research (DBER)

Understanding and Improving Learning in Undergraduate Science and Engineering

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

Undergraduate Science and Engineering Education: Goals

- Provide all students with foundational knowledge and skills
- Motivate some students to complete degrees in science or engineering
- Support students who wish to pursue careers in science or engineering

Undergraduate Science and Engineering Education: Challenges and Opportunities

- Retaining students in courses and majors
- Increasing diversity
- Improving the quality of instruction

What is Discipline-Based Education Research?

- Emerging from various parent disciplines
- Investigates teaching and learning in a given discipline
- Informed by and complementary to general research on human learning and cognition

Study Charge

- Synthesize empirical research on undergraduate teaching and learning in physics, chemistry, engineering, biology, the geosciences, and astronomy.
- Examine the extent to which this research currently influences undergraduate science instruction.
- Describe the intellectual and material resources that are required to further develop DBER.

Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research

- **SUSAN SINGER** (Chair), Carleton College
- **ROBERT BEICHNER**, North Carolina State University
- **STACEY LOWERY BRETZ,** Miami University
- **MELANIE COOPER**, Clemson University
- **SEAN DECATUR**, Oberlin College
- **JAMES FAIRWEATHER**, Michigan State University
- **KENNETH HELLER**, University of Minnesota
- **KIM KASTENS**, Columbia University
- **MICHAEL MARTINEZ**, University of California, Irvine
- **DAVID MOGK**, Montana State University
- **LAURA R. NOVICK**, Vanderbilt University
- **MARCY OSGOOD**, University of New Mexico
- **TIMOTHY F. SLATER**, University of Wyoming
- **KARL A. SMITH**, University of Minnesota and Purdue University
- **WILLIAM B. WOOD**, University of Colorado

Structure of the Report

- Section I. Status of Discipline-Based Education Research
- Section II. Contributions of Discipline-Based Education Research
- Section III. Future Directions for Discipline-Based Education Research

Section I. Status of Discipline-Based Education Research

Status of DBER: Goals

- Understand how people learn the concepts, practices, and ways of thinking of science and engineering.
- Understand the nature and development of expertise in a discipline.
- Help to identify and measure appropriate learning objectives and instructional approaches that advance students toward those objectives.
- Contribute to the knowledge base in a way that can guide the translation of DBER findings to classroom practice.
- Identify approaches to make science and engineering education broad and inclusive.

Status of DBER: Types of Knowledge Required To Conduct DBER

- Deep disciplinary knowledge
- The nature of human thinking and learning as they relate to a discipline
- Students' motivation to understand and apply findings of a discipline
- Research methods for investigating human thinking, motivation, and learning

Status of DBER: Conclusions

- DBER is a collection of related research fields rather than a single, unified field. (Conclusion 1)
- High-quality DBER combines expert knowledge of:
  - a science or engineering discipline,
  - learning and teaching in that discipline, and
  - the science of learning and teaching more generally.

  (Conclusion 4)

Section II. Contributions of Discipline-Based Education Research

Contributions of DBER: Conceptual Understanding and Conceptual Change

- In all disciplines, undergraduate students have incorrect ideas and beliefs about fundamental concepts. (Conclusion 6)
- Students have particular difficulties with concepts that involve very large or very small temporal or spatial scales. (Conclusion 6)
- Several types of instructional strategies have been shown to promote conceptual change.

Contributions of DBER: Problem Solving and the Use of Representations

- As novices in a domain, students are challenged by important aspects of the domain that can seem easy or obvious to experts. (Conclusion 7)
- Students can be taught more expert-like problem-solving skills and strategies to improve their understanding of representations.

Contributions of DBER: Research on Effective Instruction

- Effective instruction includes a range of well-implemented, research-based approaches. (Conclusion 8)

- Involving students actively in the learning process can enhance learning more effectively than lecturing.

Section III. Future Directions for Discipline-Based Education Research

Future Directions for DBER: Translating DBER into Practice

- Available evidence suggests that DBER and related research have not yet prompted widespread changes in teaching practice among science and engineering faculty. (Conclusion 12)
- Efforts to translate DBER and related research into practice are more likely to succeed if they:
  - are consistent with research on motivating adult learners,
  - include a deliberate focus on changing faculty conceptions about teaching and learning,
  - recognize the cultural and organizational norms of the department and institution, and
  - work to address those norms that pose barriers to change in teaching practice. (Conclusion 13)

Future Directions for DBER: Recommendations for Translating DBER Into Practice

- **RECOMMENDATION:** With support from institutions, disciplinary departments, and professional societies, faculty should adopt evidence-based teaching practices.

- **RECOMMENDATION**: Institutions, disciplinary departments, and professional societies should work together to prepare current and future faculty to apply the findings of DBER and related research, and then include teaching effectiveness in evaluation processes and reward systems throughout faculty members' careers. (Paraphrased)

Future Directions for DBER: Advancing DBER through Collaborations

- Collaborations among the fields of DBER, and among DBER scholars and scholars from related disciplines, although relatively limited, have enhanced the quality of DBER. (Conclusion 15)

Future Directions for DBER: Research Infrastructure

- Advancing DBER requires a robust infrastructure for research. (Conclusion 16)
- **RECOMMENDATION**: Science and engineering departments, professional societies, journal editors, funding agencies, and institutional leaders should:
  - clarify expectations for DBER faculty positions,
  - emphasize high-quality DBER work,
  - provide mentoring for new DBER scholars, and
  - support venues for DBER scholars to share their research findings

Future Directions for DBER: Some Key Elements of a Research Agenda

- Studies of similarities and differences among different groups of students
- Longitudinal studies
- Additional basic research in DBER
- Interdisciplinary studies of cross-cutting concepts and cognitive processes
- Additional research on the translational role of DBER

Acknowledgements

- National Science Foundation, Division of Undergraduate Education (Grant No. 0934453)
- Various volunteers:
  - Committee
  - Fifteen reviewers
  - Report Review Monitor (Susan Hanson, Clark University) and Coordinator (Adam Gamoran, University of Wisconsin-Madison)
- Commissioned paper authors
- NRC staff (Natalie Nielsen, Heidi Schweingruber, Margaret Hilton)

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Status, Contributions, and Future Direction of Discipline-Based Education Research (DBER)

The National Science Foundation has funded a synthesis study on the status, contributions, and future direction of discipline-based education research (DBER) in physics, biological sciences, geosciences, and chemistry. DBER combines knowledge of teaching and learning with deep knowledge of discipline-specific science content. It describes the discipline-specific difficulties learners face and the specialized intellectual and instructional resources that can facilitate student understanding.

This 30-month study will build on two workshops held in 2008 to explore Evidence on Promising Practices in Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Education. It will answer questions that are essential to advancing DBER and broadening its impact on undergraduate science teaching and learning. An interdisciplinary panel of experts will synthesize empirical research on undergraduate teaching and learning in the sciences; explore the extent to which this research currently influences undergraduate instruction; and identify the intellectual and material resources required to further develop DBER.

The final product will be a consensus report that will provide guidance for future DBER research. In addition, the findings and recommendations of this study may invite, if not assist, postsecondary institutions to:

- increase interest and research activity in DBER, and improve its quality and usefulness, across all natural science disciplines
- guide instruction and assessment across natural science courses to improve student learning
- bring greater focus to issues of student attrition in the natural sciences that are related to quality of instruction

MEETINGS	LOCATION	RESOURCES
Committee Meeting 1 June 28-29, 2010	Keck Center, Room 101 500 5th Street, NW Washington, DC	Agenda
Committee Meeting 2 October 18-19, 2010	Keck Center, Room 201 500 5th Street, NW Washington, DC (limited space)	Agenda *includes links to papers and presentations*; Presentations; Commissioned Papers
Committee Meeting 3 December 3-4, 2010	Beckman Center Irvine, CA	Agenda *includes links to papers and presentations*; Commissioned Papers
Committee Meeting 4	Keck Center, 500 5th Street, NW Washington, DC (limited space)	Agenda; Commissioned Papers
Committee Meeting 5	Jonsson Center Woods Hole, MA	*This meeting is closed to the public*

COMMITTEE

Committee Membership

STAFF

Natalie Nielsen Study Director
Heidi Schweingruber, Deputy Director, BOSE
Margaret Hilton, Senior Program Officer, BOSE
Anthony Brown, Senior Program Assistant, BOSE

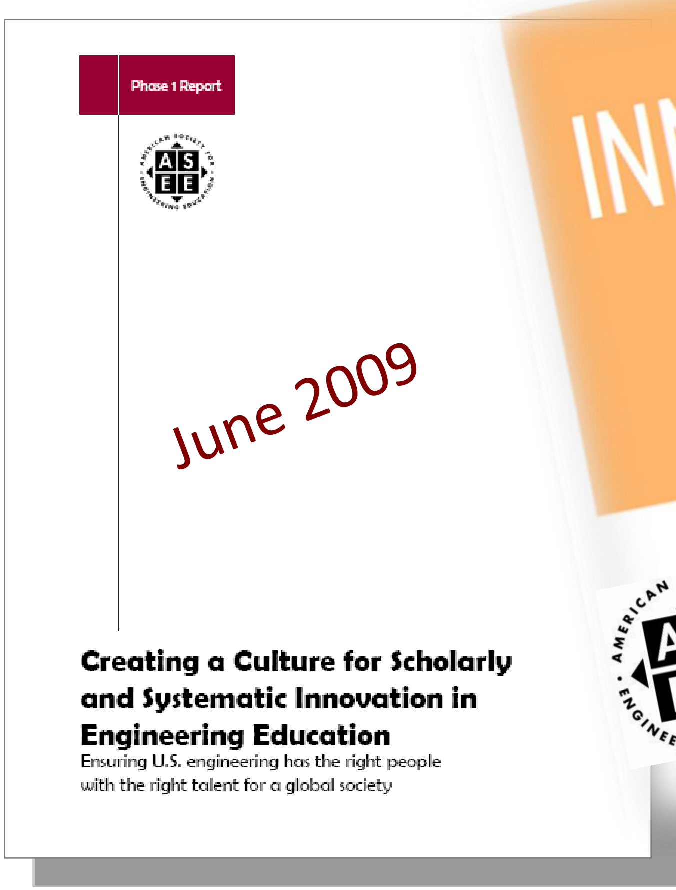
Feedback | Back to Top

http://www7.nationalacademies.org/bose/DBER_Homepage.html

Emphasis on Innovation

- ASEE Innovation with Impact report
  - Excerpt from Presentation by Leah Jamieson, Dean, College of Engineering, Purdue
- NAE Engineering Education Research and Innovation Activities
  - Briefing by Beth Cady, Program Officer, Engineering Education, National Academy of Engineering

ASEE Reports - A Path Forward


Phase 1 Report

Creating a Culture for Scholarly and Systematic Innovation in Engineering Education

Ensuring U.S. engineering has the right people with the right talent for a global society

June 2009


INNOVATION WITH IMPACT

Creating a Culture for Scholarly and Systematic Innovation in Engineering Education

American Society for Engineering Education

June 2012

PURDUE ENGINEERING *Think impact.*

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.

PURDUE ENGINEERING Think impact.

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.

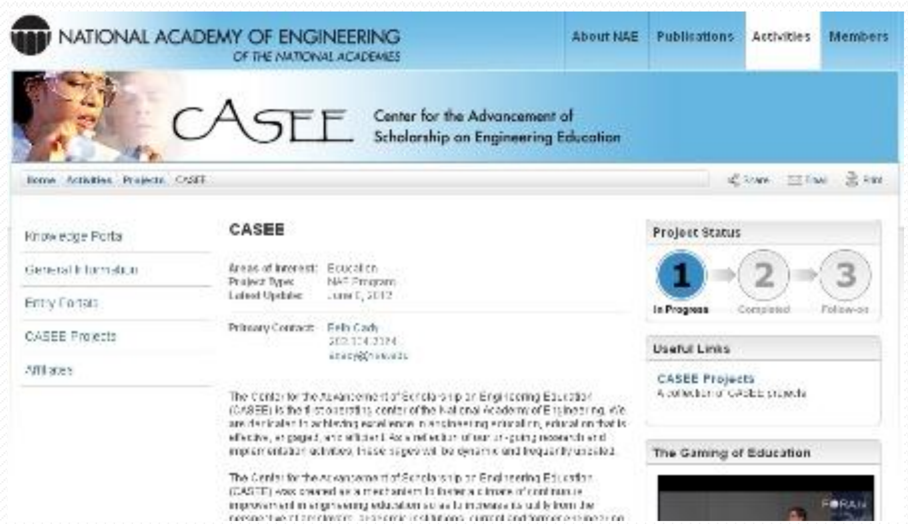
National Academy of Engineering

Engineering Education Research and Innovation Activities

Beth Cady
Program Officer, Engineering Education
ecady@nae.edu

Center for the Advancement of Scholarship on Engineering Education

- Created to foster continuous improvement
- Extensive set of resources at www.nae.edu/casee
  - Research-to-Practice documents
  - Meeting agendas and reports of CASEE projects
  - Equity-related resources
  - Videos
  - Summaries



- Please help us organize the site!
  - Search terms, categories

Real-World Engineering Education

- Sponsored by AMD
- Innovative programs infusing real-world experiences
- Final publication to be released over the summer
- Includes program description and discussion of barriers/solutions

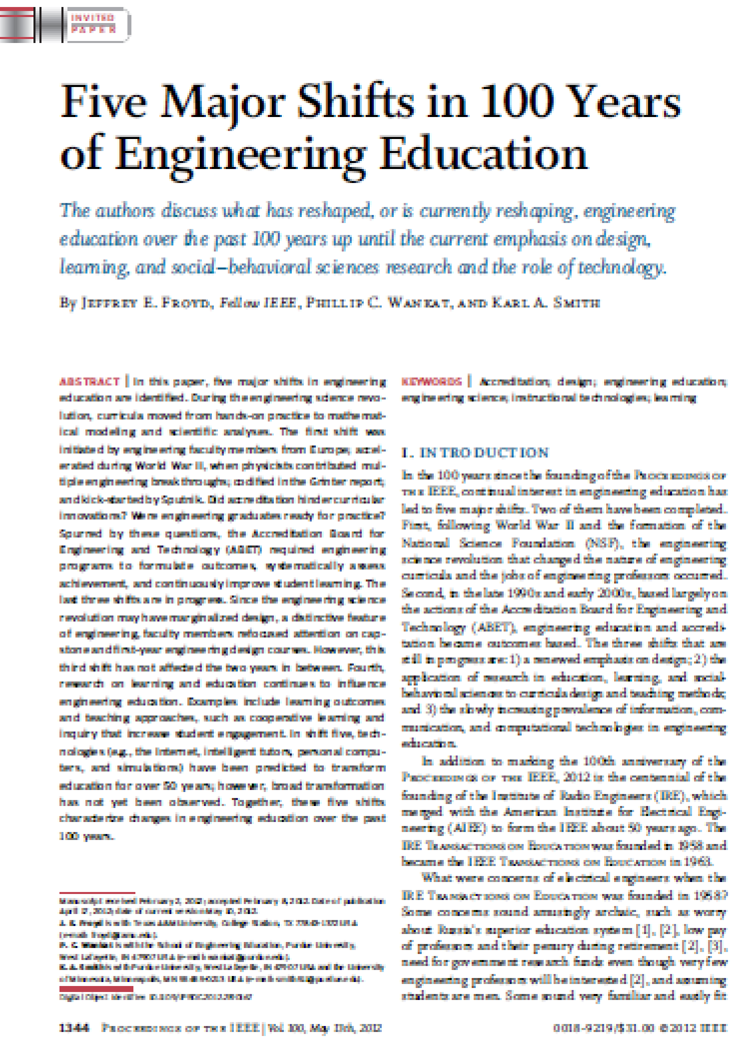
Frontiers of Engineering Education (FOEE)

- Catalyze a vibrant community of *emerging* engineering education leaders
- Recognize faculty accomplishment, facilitate learning, broaden collaboration, and promote dissemination of innovative practice in engineering education

FOEE (continued)

- Attendees share their work with peers
- Speakers on topics of interest to attendees
- Speakers/Coaches provide mentoring advice
- Opportunities to network with peers and coaches

- 150 alums
- Nominations for 2012 currently open
  - Nominations from dean or NAE member
  - Applications due in July
- Symposium will be October 14-17 in Irvine, CA



INVITED PAPER

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

ABSTRACT | In this paper, five major shifts in engineering education are identified. During the engineering science revolution, curricula moved from hands-on practice to mathematical modeling and scientific analyses. The first shift was initiated by engineering faculty members from Europe, accelerated during World War II, when physicists contributed multiple engineering breakthroughs; codified in the Grinter report; and kick-started by Sputnik. Did accreditation hinder curricular innovations? Were engineering graduates ready for practice? Spurred by these questions, the Accreditation Board for Engineering and Technology (ABET) required engineering programs to formulate outcomes, systematically assess achievement, and continuously improve student learning. The last three shifts are in progress. Since the engineering science revolution may have marginalized design, a distinctive feature of engineering, faculty members refocused attention on capstone and first-year engineering design courses. However, this third shift has not affected the two years in between. Fourth, research on learning and education continues to influence engineering education. Examples include learning outcomes and teaching approaches, such as cooperative learning and inquiry that increase student engagement. In shift five, technologies (e.g., the Internet, intelligent tutors, personal computers, and simulations) have been predicted to transform education for over 50 years; however, broad transformation has not yet been observed. Together, these five shifts characterize changes in engineering education over the past 100 years.

KEYWORDS | Accreditation; design; engineering education; engineering science; instructional technologies; learning

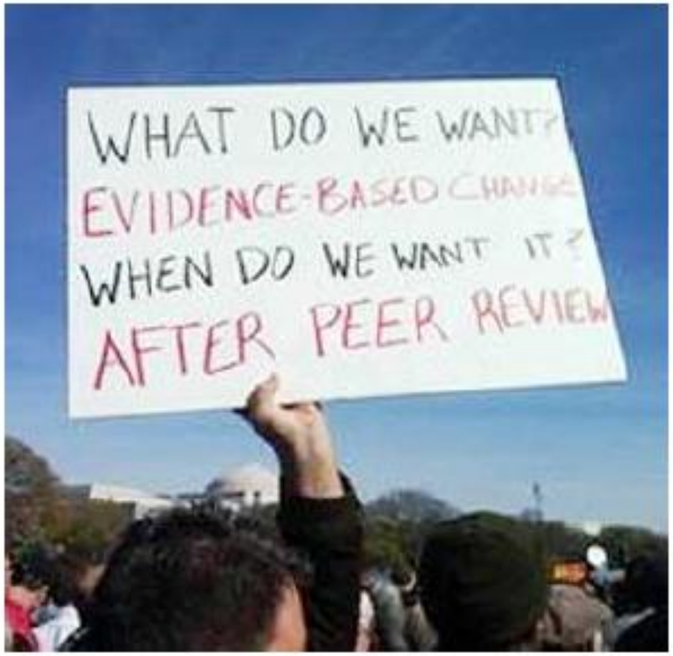
I. INTRODUCTION

In the 100 years since the founding of the Proceedings of the IEEE, continual interest in engineering education has led to five major shifts. Two of them have been completed. First, following World War II and the formation of the National Science Foundation (NSF), the engineering science revolution that changed the nature of engineering curricula and the jobs of engineering professors occurred. Second, in the late 1990s and early 2000s, based largely on the actions of the Accreditation Board for Engineering and Technology (ABET), engineering education and accreditation became outcomes based. The three shifts that are still in progress are: 1) a renewed emphasis on design; 2) the application of research in education, learning, and social-behavioral sciences to curricula design and teaching methods; and 3) the slowly increasing prevalence of information, communication, and computational technologies in engineering education.

In addition to marking the 100th anniversary of the Proceedings of the IEEE, 2012 is the centennial of the founding of the Institute of Radio Engineers (IRE), which merged with the American Institute for Electrical Engineering (AIEE) to form the IEEE about 50 years ago. The IRE Transactions on Education was founded in 1958 and became the IEEE Transactions on Education in 1963.

What were concerns of electrical engineers when the IRE Transactions on Education was founded in 1958? Some concerns sound amazingly archaic, such as worry about Russia's superior education system [1], [2], low pay of professors and their penury during retirement [2], [3], need for government research funds even though very few engineering professors will be interested [2], and assuming students are men. Some sound very familiar and easily fit

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.



The Challenges of Spreading and Sustaining Research-Based Instruction in Undergraduate STEM

Charles Henderson

*Western Michigan University

homepages.wmich.edu/~chenders

119th ASEE Conference & Exposition

June 13, 2012

San Antonio, TX

Awards: #0715698, #1022186, #0623009, #0723699

http://homepages.wmich.edu/~chenders/Publications/2012HendersonASEETalk.pdf

What are options in approaching change?

Aspect of System to be Changed		Intended Outcome: Prescribed	Intended Outcome: Emergent
	Individuals	Disseminating: Curriculum and Pedagogy	Developing: Reflective Teachers
	Environments and Structures	Developing: Policy	Developing: Shared Vision

Henderson, C., Finkelstein, N., & Beach, A. (2010). Beyond dissemination in college science teaching: An introduction to four core change strategies. *Journal of College Science Teaching, 39*(5), 18-25.

Change and Resistance

- Resistance is inevitable.

Change and Resistance

- Resistance is inevitable.
- Options
  - **Ignoring** resistance seldom works
  - Trying to **steamroll** resistance seldom works, e.g., you will be convinced by my data
  - **Anticipate and address** resistance offers better results
  - **Engaging** resistance tends to offer the best results

Mauer, R. (1996). *Beyond the Wall of Resistance: Unconventional Strategies that Build Support for Change*. Austin, TX: Bard Press.

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://CLEERhub.org

http://www.ce.umn.edu/~smith/links.html

Facilitated By

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