Welcome

Colloquium on P-12 STEM Education Research

University of Minnesota

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St. Paul, MN
14-16 August, 2011

Colloquium 2011 Advisory Board

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Platinum sponsorship:

3M STEM Education Center

Gold sponsorship:

University of Minnesota Extension
Driven to Discover℠

nylc
national youth leadership council

Silver sponsorship:

Mayo Clinic

hp

CEHD
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This is an open MN STEM Network event through our partnership with:

MINNESOTA STEM NETWORK
POWERING STEM LEARNING AND INNOVATION ACROSS MINNESOTA

AN INITIATIVE OF SCIMATH MN

Engineering Education: Advancing the Practice
Karl 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

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

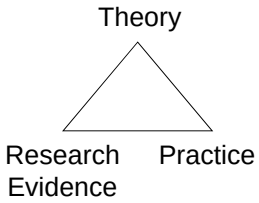
$$v_y \frac{dc}{dy} = D\frac{d^2 c}{dy^2}$$

First Teaching Experience

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

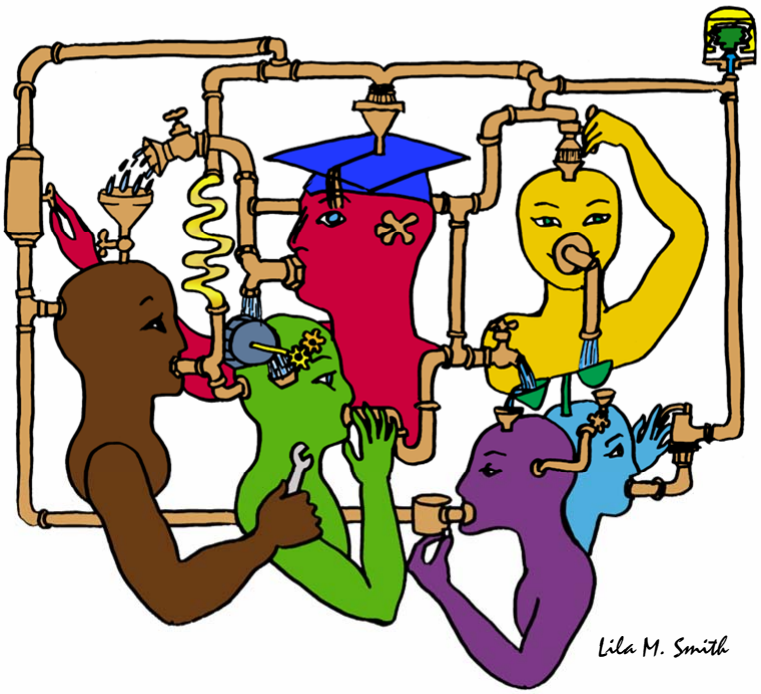
Engineering Education

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



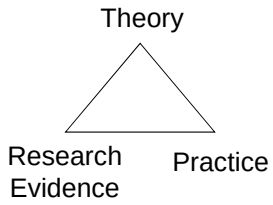
University of Minnesota College of Education
Social, Psychological and Philosophical
Foundations of Education

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



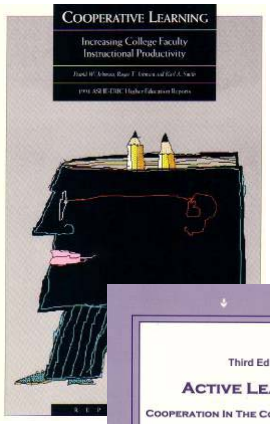
Cooperative Learning

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



Lewin's Contributions

- Founded field of social psychology
- Action Research
- Force-Field analysis
- B = f(P,E)
- Social Interdependence Theory
- "There is nothing so practical as a good theory"



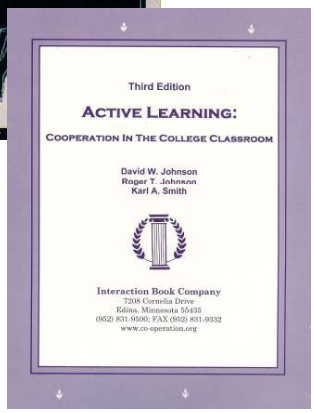
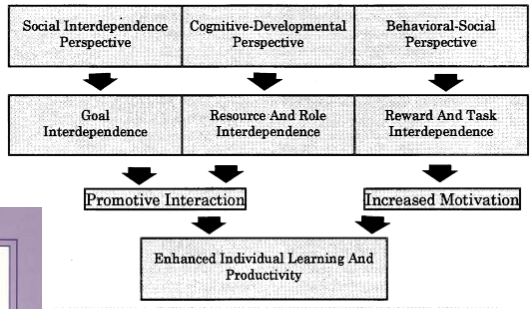


Figure A.1 A General Theoretical Framework



Cooperative Learning

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

15 [*First edition 1991]

Cooperative Learning Research Support

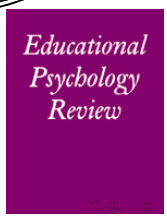
Johnson, D.W., Johnson, R.T., & Smith, K.A. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change*, *30* (4), 26-35.

- 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

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STEM

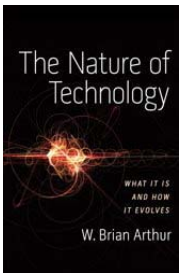
Science – Technology – Engineering – Mathematics

- Science & Mathematics – Prevalent
- Engineering & Technology – Less Prevalent
- STEM Integration – How?

Definitions (OED)

- Technology –
  - systematic treatment of art, craft
  - Sanskrit
- Engineering –
  - The action of the verb ENGINEER; the work done by, or the profession of, an engineer
- Smith –
  - One who works in iron or other metal
  - Original sense – craftsman, skilled worker in metal, wood or other material

Technology



Three definitions of technology (Arthur, 2009)

1. A means to fulfill a human purpose
2. An assemblage of practices and components
3. The entire collection of devices and engineering practices available to a culture

Three fundamental principles (Arthur, 2009):

1. All technologies are combinations
2. Each component of technology is itself in miniature a technology
3. All technologies harness and exploit some effect or phenomena, usually several

Engineering

A scientist discovers that which exists. An engineer creates that which never was - Theodore von Kármán (1881-1963)

Engineering = Design

Design in a major sense is the essence of engineering; it begins with the identification of a need and ends with a product or system in the hands of a user. It is primarily concerned with synthesis rather than the analysis which is central to engineering science. Design, above all else, distinguishes engineering from science (Hancock, 1986, National Science Foundation Workshop).

Design defines engineering. It's an engineer's job to create new things to improve society. It's the University's obligation to give students fundamental education in design (William Durfee, ME, U of Minnesota, *Minnesota Technolog*, Nov/Dec 1994).

Engineering

The engineering method is the use of heuristics to cause the best change in a poorly understood situation within the available resources – (Koen, 1971, 2000)

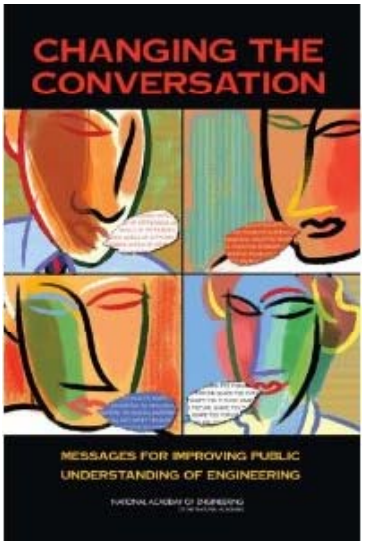
The engineering method is design under constraints – Wm. Wulf, Past President, U.S. National Academy of Engineering

Engineering in Popular Media

- "Houston, we've got a problem." Apollo 13
- MacGyver?
- Myth Busters?
- Petroski
- Dilbert

Dilbert

Changing the Conversation



Emphasis on Innovation

- NSF TUES (CCLI) PI Meeting
  - TUES (Transforming Undergraduate Education in STEM)
  - Myles Boylan presentation
  - Carl Wieman presentation – White House – Office of Science and Technology Policy
  - http://ccliconference.org/meetings/2011-tues-conference/
- NAE FOEE
  - http://www.nae.edu/Activities/Projects20676/CASEE/26338/35816/FOEE.aspx

The Federal Environment for STEM Education Programs: Implications for TUES

& Some of your suggestions

Myles Boylan
Division of Undergraduate Education
National Science Foundation
CCLI PI Meeting January 28, 2011

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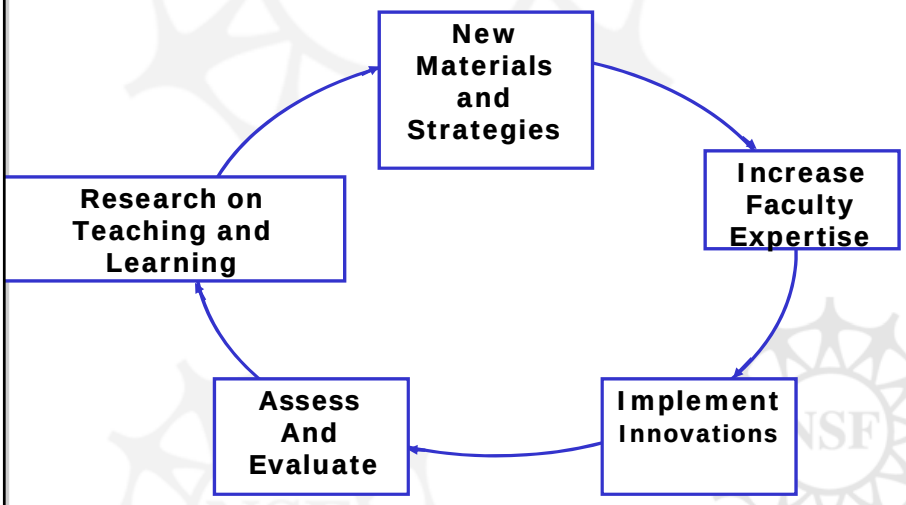
Cyclic Model for Creating Knowledge and Improving Practices in STEM Education



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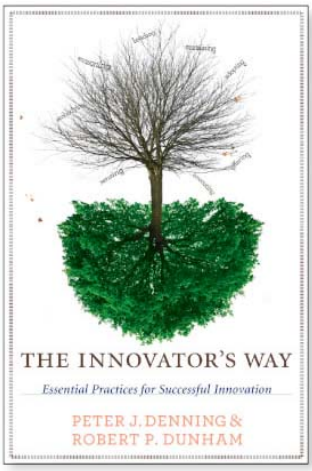
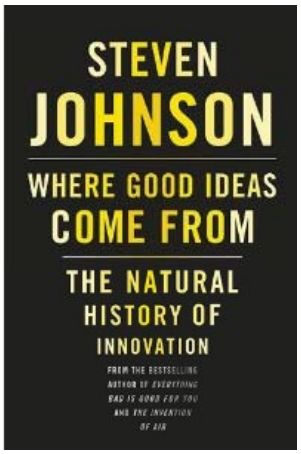
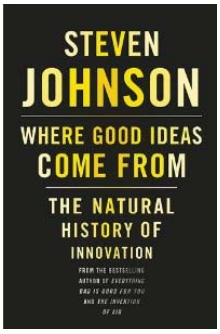
Measuring Impact in STEM Ed; Are they thinking like experts?

Carl Wieman
Assoc. Director for Science
White House Office of Science and Technology Policy

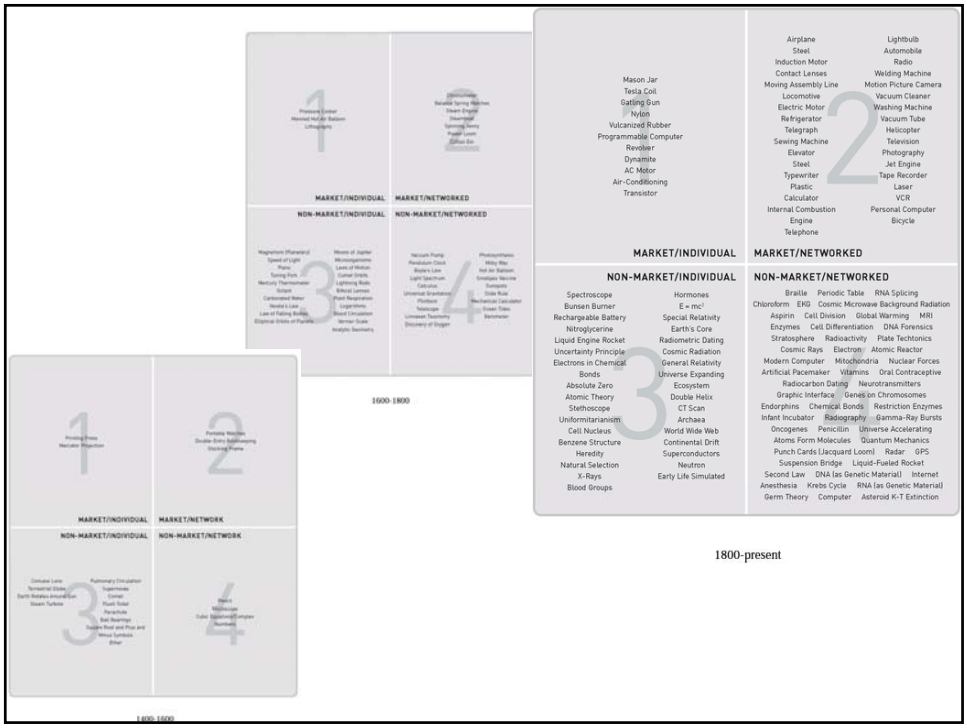


Innovation is the adoption of a new practice in a community - Denning & Dunham (2010)





1. What is the distribution of innovations?
2. Did it change over time? If so, how?
3. Where does **your** innovation fit?



It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become **designers** of learning experiences, processes, and environments.

James Duderstadt, 1999 [Nuclear Engineering Professor; Former Dean, Provost and President of the University of Michigan]