Cooperative Learning: An Evidence-Based Practice for Innovative Education

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Teaching and Learning Center

King Fahd University of Petroleum and Minerals

26 August 2012

Overview

- Seminar
  - Welcome & Overview
  - Cooperative Learning Basics & Rationale
  - Course Design Foundations
- Workshop Preview – Formal Cooperative Learning – Design, Implementation and Assessment
  - Informal Cooperative Learning (Brief Summary)
    - Book Ends on a Class Session
  - Formal Cooperative Learning
    - Problem-Based Cooperative Learning

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Participant Learning Goals (Objectives)

- Describe key features of Cooperative Learning
- Describe key features of the Understanding by Design and How People Learn
- Explain rationale for Pedagogies of Engagement, especially Cooperative Learning & Challenge Based Learning
- Apply cooperative learning to classroom practice
- Identify connections between cooperative learning and desired outcomes of courses and programs

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Cooperative Learning and Engineering Education Karl Smith

Research
•Process Metallurgy 1970 -1992
•Learning ~1974
•Design ~1995
•Engineering Education Research & Innovation ~ 2000
•STEM Education ~ 2010

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

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

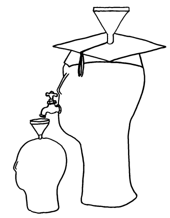
$$v_y \frac{dc}{dy} = D\frac{d^2c}{dy^2}$$

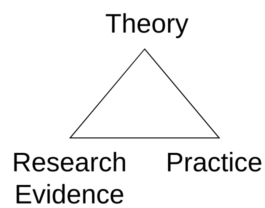
First Teaching Experience

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

Engineering Education

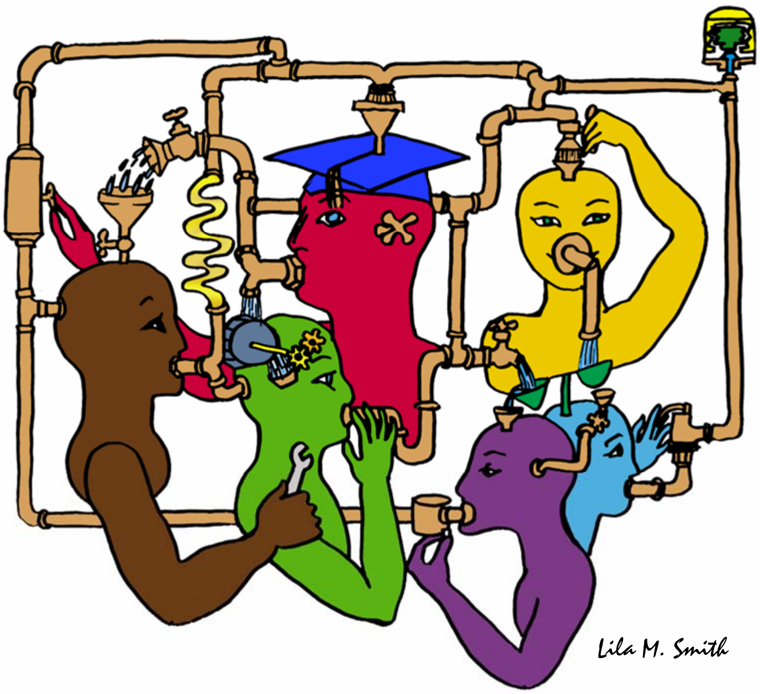
- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics
- Research – ?
- Theory – ?





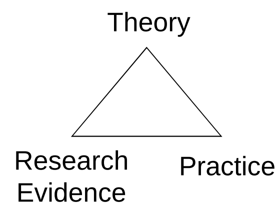
University of Minnesota College of Education
Social, Psychological and Philosophical
Foundations of Education

- Statistics, Measurement, Research Methodology
- Assessment and Evaluation
- Learning and Cognitive Psychology
- Knowledge Acquisition, Artificial Intelligence, Expert Systems
- Development Theories
- Motivation Theories
- 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



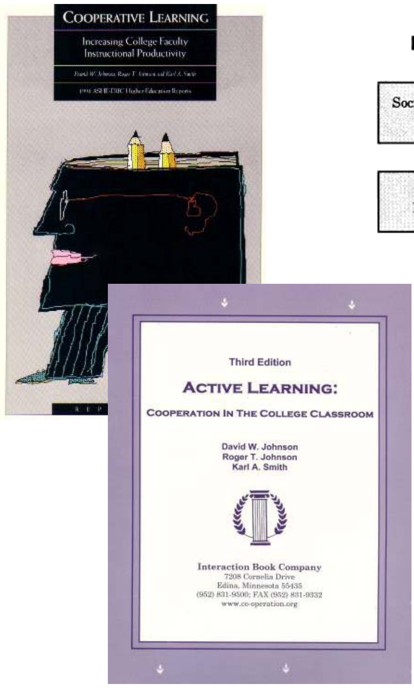
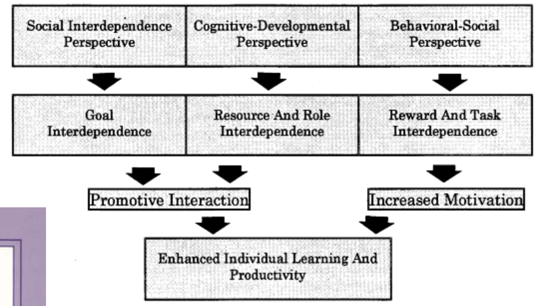


Figure A.1 A General Theoretical Framework



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

[*First edition 1991]

Cooperative Learning Research Support

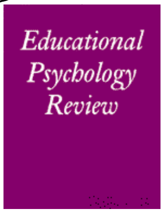
Johnson, D.W., Johnson, R.T., & Smith, K.A. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change*, *30* (4), 26-35.

- 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

Cooperative Learning is instruction that involves people working in teams to accomplish a common goal, under conditions that involve both *positive interdependence* (all members must cooperate to complete the task) and *individual and group accountability* (each member is accountable for the complete final outcome).

Key Concepts

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


Cooperative Learning
Positive Interdependence
Individual Accountability
Face-to-Face Interaction

http://www.ce.umn.edu/~smith/docs/Smith-CL%20Handout%2008.pdf

Seven Principles for Good Practice in Undergraduate Education

- Good practice in undergraduate education:
  - – Encourages student-faculty contact
  - – Encourages cooperation among students
  - – Encourages active learning
  - – Gives prompt feedback
  - – Emphasizes time on task
  - – Communicates high expectations
  - – Respects diverse talents and ways of learning

Chickering & Gamson, June, 1987

Student Engagement Research Evidence

- Perhaps the strongest conclusion that can be made is the least surprising. Simply put, the greater the student's involvement or engagement in academic work or in the academic experience of college, the greater his or her level of knowledge acquisition and general cognitive development …(Pascarella and Terenzini, 2005).
- Active and collaborative instruction coupled with various means to encourage student engagement invariably lead to better student learning outcomes irrespective of academic discipline (Kuh et al., 2005, 2007).

See Smith, et.al, 2005 and Fairweather, 2008, Linking Evidence and Promising Practices in Science, Technology, Engineering, and Mathematics (STEM) Undergraduate Education - http://www7.nationalacademies.org/bose/Fairweather_CommissionedPaper.pdf

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Small-Group Learning: Meta-analysis

Springer, L., Stanne, M. E., & Donovan, S. 1999. Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. Review of Educational Research, 69(1), 21-52.

Small-group (predominantly cooperative) learning in postsecondary science, mathematics, engineering, and technology (SMET). 383 reports from 1980 or later, 39 of which met the rigorous inclusion criteria for meta-analysis.

The main effect of small-group learning on achievement, persistence, and attitudes among undergraduates in SMET was significant and positive. Mean effect sizes for achievement, persistence, and attitudes were 0.51, 0.46, and 0.55, respectively.

*"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*."

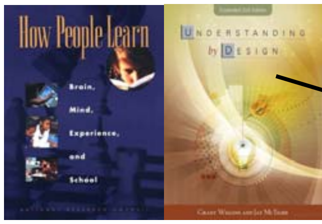
James Duderstadt, 1999
Nuclear Engineering Professor; Dean, Provost and President of the University of Michigan

What do you already know about course design?
[Background Knowledge Survey]

<u>Short Answer Questions</u>

- What do you feel are important considerations about course (re) design?
- What are challenges you have faced with course (re) design?

Design Foundations

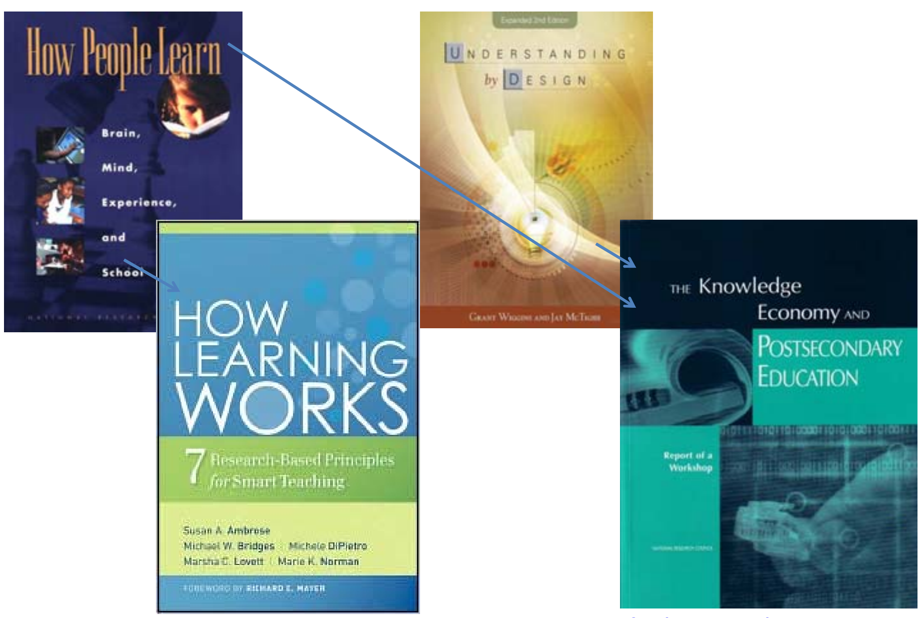


Science of Instruction (UbD)

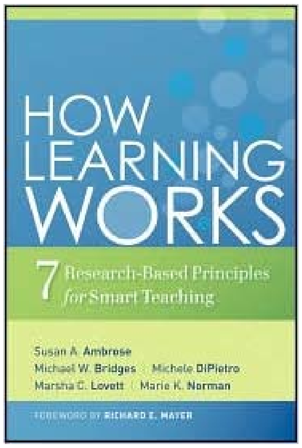
Science of Learning (HPL)

	No	**Yes**
Yes	Good Theory/ Poor Practice	Good Theory & Good Practice
No		Good Practice/ Poor Theory

Sources: Bransford, Brown & Cocking. 1999. *How people learn.* National Academy Press.
Wiggins, G. & McTighe, J. 2005. *Understanding by design, 2ed*. ASCD.



- Bransford, Vye and Bateman – Creating High Quality Learning Environments



1. Students prior knowledge can help or hinder learning
2. How student organize knowledge influences how they learn and apply what they know
3. Students' motivation determines, directs, and sustains what they do to learn
4. To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned
5. Goal-directed practice coupled with targeted feedback enhances the quality of students' learning
6. Students' current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning
7. To become self-directed learners, students must learn to monitor and adjust their approach to learning

Understanding by Design

Wiggins & McTighe (1997, 2005)

Stage 1. Identify Desired Results

- Enduring understanding
- Important to know and do
- Worth being familiar with

Stage 2. Determine Acceptable Evidence

Stage 3. Plan Learning Experiences and Instruction

Overall: *Are the desired results, assessments, and learning activities ALIGNED?*

From: Wiggins, Grant and McTighe, Jay. 1997. *Understanding by Design*. Alexandria, VA: ASCD

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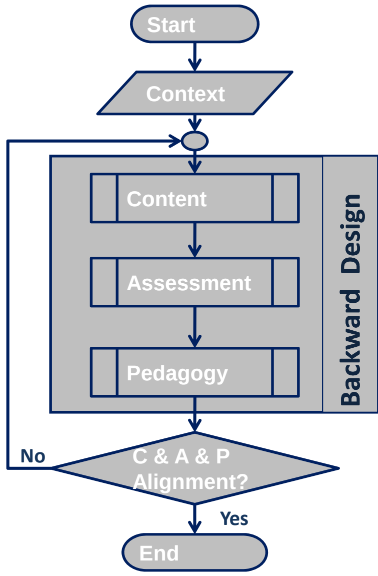
Content-Assessment-Pedagogy (CAP) Design Process Flowchart	Understanding by Design (Wiggins & McTighe, 2005)



Streveler, Smith & Pilotte (2011)

UdB – 3 Stages of Backward Design

Identify the Desired Results

Determine Acceptable Evidence

Plan Learning Experiences

Are the desired results, assessments, and learning activities ALIGNED?

UbD Filters for Curricular Priorities

- Are the topics enduring and transferable big ideas having value beyond the classroom?
- Are the topics big ideas and core processes at the heart of the discipline?
- Are the topics abstract, counterintuitive, often misunderstood, or easily misunderstood ideas requiring coverage?
- Are the topics big ideas embedded in facts, skills and activities?

Understanding by Design, pp. 10-11

Pedagogies of Engagement

The Active Learning Continuum

Make the lecture active

Informal Group Activities

Structured Team Activities

Problems Drive the Course

Instructor Centered

Student Centered

Active Learning

Collaborative Learning

Cooperative Learning

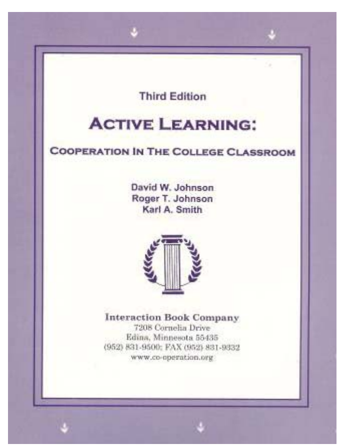
Problem-Based Learning

Prince, M. (2010). NAE FOEE

My work is situated here – Cooperative Learning & Challenge-Based Learning

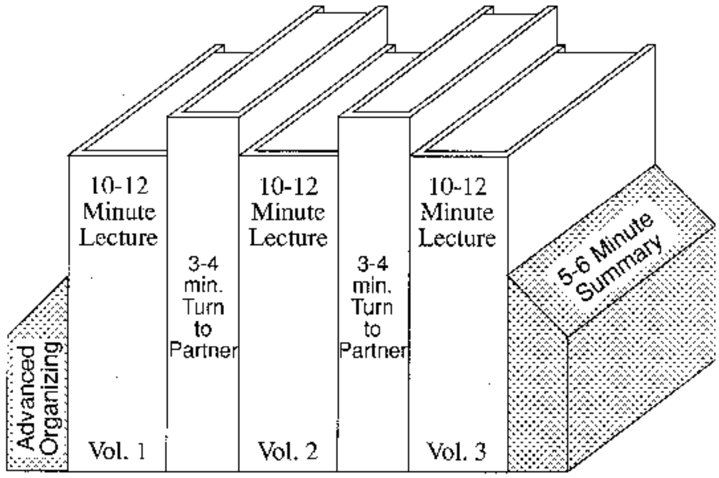
Active Learning: Cooperation in the College Classroom

- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups



See Cooperative Learning Handout (CL College-804.doc) 28

Book Ends on a Class Session



Smith, K.A. 2000. Going deeper: Formal small-group learning in large classes. Energizing large classes: From small groups to learning communities. *New Directions for Teaching and Learning*, 2000, 81, 25-46. [NDTL81Ch3GoingDeeper.pdf]

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Informal CL (Book Ends on a Class Session) with Concept Tests

Physics
- Peer Instruction
- Eric Mazur - Harvard – http://galileo.harvard.edu
  - Peer Instruction – www.prenhall.com
- Richard Hake – http://www.physics.indiana.edu/~hake/

Chemistry
- Chemistry ConcepTests - UW Madison
- www.chem.wisc.edu/~concept

Video: Making Lectures Interactive with ConcepTests
- ModularChem Consortium – http://mc2.cchem.berkeley.edu/

STEMTEC
Video: How Change Happens: Breaking the “Teach as You Were Taught” Cycle – Films for the Humanities & Sciences – www.films.com

Harvard – Derek Bok Center
Thinking Together & From Questions to Concepts: Interactive Teaching in Physics – www.fas.harvard.edu/~bok_cen/

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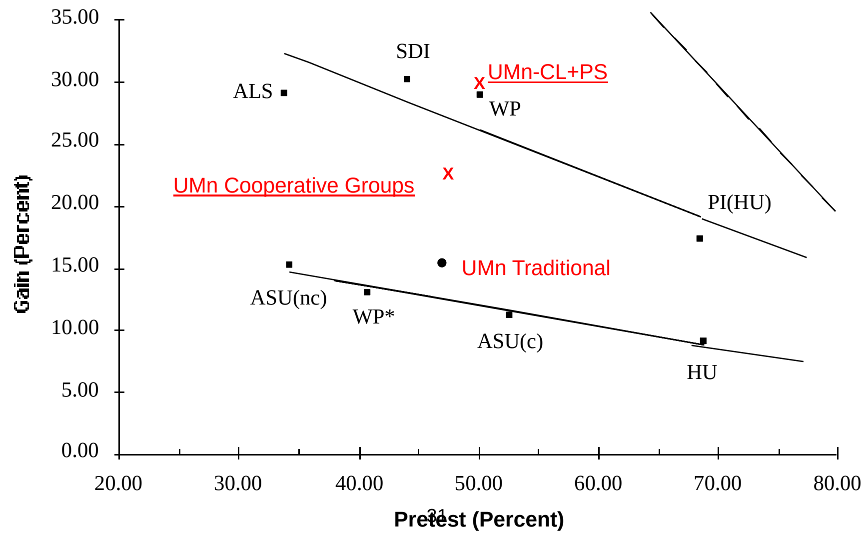
The “Hake” Plot of FCI



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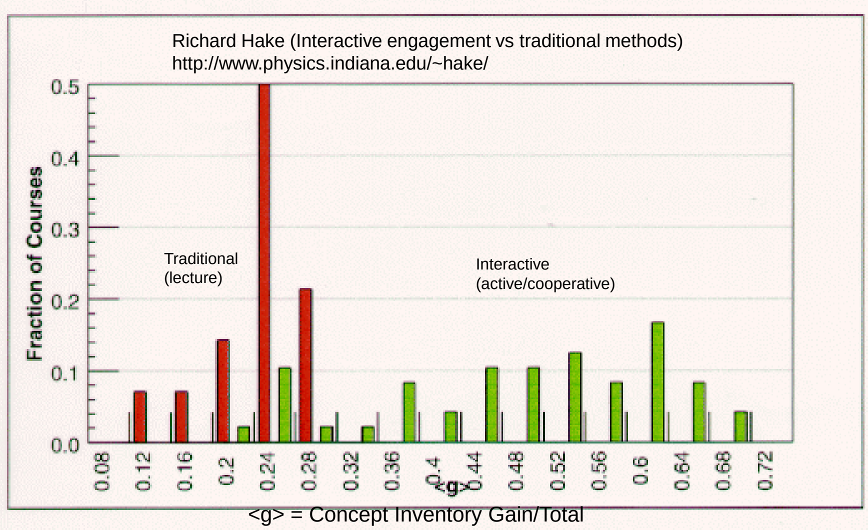

Fig. 2. Histogram of the average normalized gain <g>: dark (red) bars show the *fraction* of 14 traditional courses (N = 2084), and light (green) bars show the *fraction* of 48 interactive engagement courses (N = 4458), both within bins of width δ<g> = 0.04 centered on the <g> values shown.

III. CONCEPTUAL TEST RESULTS

A. Gain vs Pretest Graph - All Data

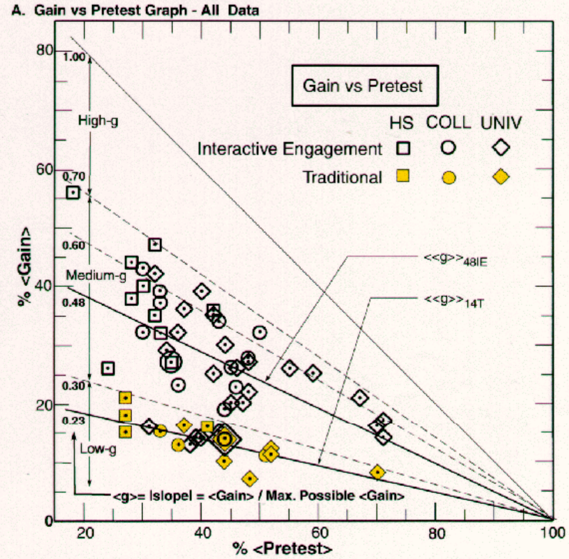

Fig. 1. %<Gain> vs %<Pretest> score on the conceptual Mechanics Diagnostic (MD) or Force Concept Inventory (FCI) tests for 62 courses enrolling a total N = 6542 students: 14 traditional (T) courses (N = 2084) which made little or no use of interactive engagement (IE) methods, and 48 IE courses (N = 4458) which made considerable use of IE methods. Slope lines for the average of the 14 T courses $<<g>>_{14T}$ and 48 IE courses $<<g>>_{48IE}$ are shown, as explained in the text.

Cooperative Learning Adopted

The American College Teacher:

National Norms for 2007-2008

Methods Used in "All" or "Most"	All – 2005	All – 2008	Assistant - 2008
Cooperative Learning	48	59	66
Group Projects	33	36	61
Grading on a curve	19	17	14
Term/research papers	35	44	47

http://www.heri.ucla.edu/index.php

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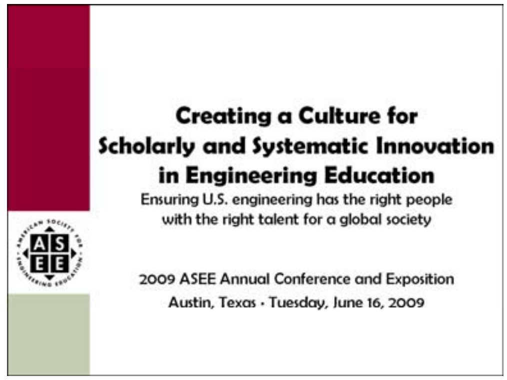
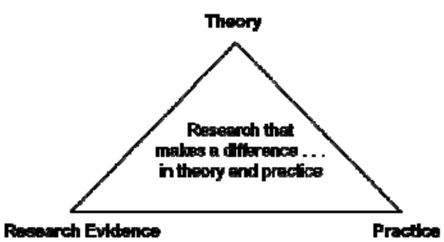
Celebration of Two Major ASEE Milestones

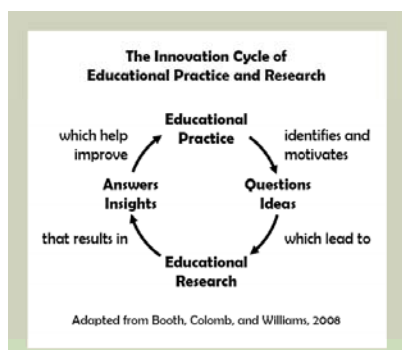


2011 ASEE Annual Conference and Exposition

Vancouver, British Columbia • Monday, June 27, 2011

One BIG Idea; Two Perspectives





THE RESEARCH JOURNAL FOR ENGINEERING EDUCATION — JEE

Jamieson & Lohmann (2009)

Engineering Education Innovation

ASEE Main Plenary, 8:45 a.m. – 10:15 a.m.
Vancouver International Conference Centre, West Ballroom CD
Expected to draw over 2,000 attendees, this year's plenary features Karl A. Smith, Cooperative Learning Professor of Engineering Education at Purdue University and Morse–Alumni Distinguished Teaching Professor & Professor of Civil Engineering at the University of Minnesota.
Smith has been at the University of Minnesota since 1972 and has been active in ASEE since he became a member in 1973. For the past five years, he has been helping start the engineering education Ph.D. program at Purdue University. He is a Fellow of the American Society for Engineering Education and past Chair of the Educational Research and Methods Division. He has worked with thousands of faculty all over the world on pedagogies of engagement, especially cooperative learning, problem-based learning, and constructive controversy.
On the occasion of the 100th anniversary of the Journal of Engineering Education and the release of ASEE's Phase II report *Creating a Culture for Scholarly and Systematic Innovation in Engineering Education* (Jamieson/Lohmann report), the plenary will celebrate these milestones and demonstrate rich, mutual interdependences between practice and inquiry into teaching and learning in engineering education. Depth and range of the plenary will energize the audience and reflects expertise and interests of conference participants. One of ASEE's premier educators and researchers, Smith will draw upon our roots in scholarship to set the stage and weave the transitions for six highlighted topics selected for their broad appeal across established, evolving, and emerging practices in engineering education.

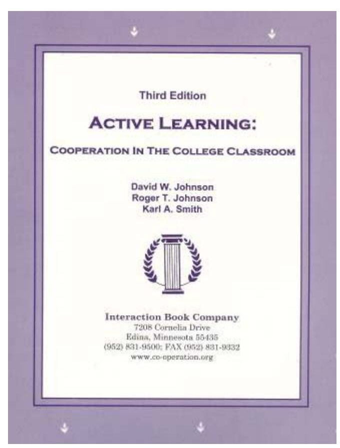
Highlights from Monday:

Monday's **Main Plenary** by Karl A. Smith, Cooperative Learning Professor of Engineering Education at Purdue University and Morse-Alumni Distinguished Teaching Professor & Professor of Civil Engineering at the University of Minnesota, focused on six highlighted topics (presented by six different educators) selected for their broad appeal across established, evolving, and emerging practices in engineering education.

Video: https://secure.vimeo.com/27147996
Slides: http://www.ce.umn.edu/~smith/links.html
http://www.asee.org/conferences-and-events/conferences/annual-conference/2011/program-schedule/conference-highlights

Active Learning: Cooperation in the College Classroom

- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups



See Cooperative Learning Handout (CL College-804.doc)

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Professor's Role in Formal Cooperative Learning

1. Specifying Objectives
2. Making Decisions
3. Explaining Task, Positive Interdependence, and Individual Accountability
4. Monitoring and Intervening to Teach Skills
5. Evaluating Students' Achievement and Group Effectiveness

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Formal Cooperative Learning – Types of Tasks

1. **Jigsaw – Learning new conceptual/procedural material**
2. Peer Composition or Editing
3. **Reading Comprehension/Interpretation**
4. **Problem Solving, Project, or Presentation**
5. Review/Correct Homework
6. Constructive Academic Controversy
7. **Group Tests**

Problem-Based Cooperative Learning

At M.I.T., Large Lectures Are Going the Way of the Blackboard

Jodi Hilton for The New York Times

The Massachusetts Institute of Technology has changed the way it offers some introductory classes. Prof. Gabriella Sciolla at a class on electricity and magnetism.

By SARA RIMER
Published: January 12, 2009

COMMENTS (00)
E-MAIL
PRINT
SINGLE PAGE

CAMBRIDGE, Mass. — For as long as anyone can remember, introductory physics at the Massachusetts Institute of Technology was taught in a vast windowless amphitheater known by its number,

January 13, 2009—New York Times – http://www.nytimes.com/2009/01/13/us/13physics.html?em

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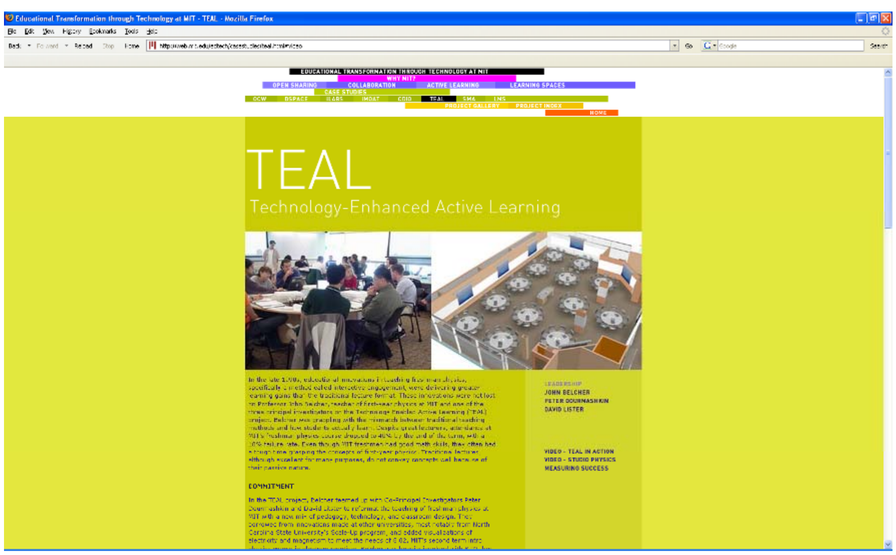

http://web.mit.edu/edtech/casestudies/teal.html#video

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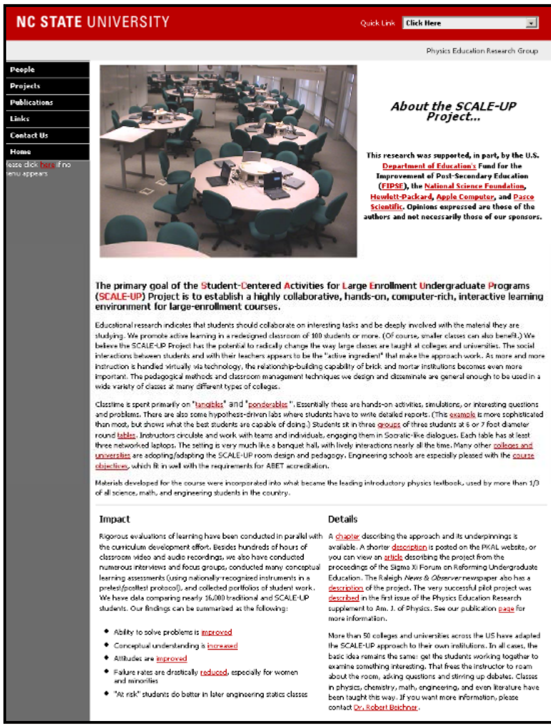

http://www.ncsu.edu/PER/scaleup.html

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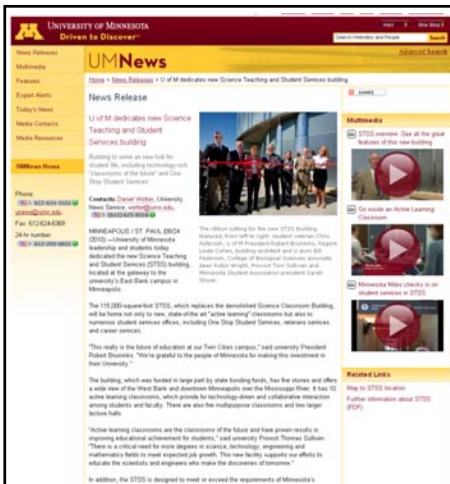

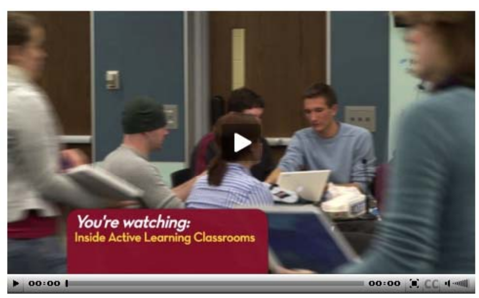

http://mediamill.cla.umn.edu/mediamill/embed/78755

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

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

Afternoon Session Preview

- Design and Implementation of Active and Cooperative Learning
  - Pedagogies of Engagement – Cooperative Learning and Challenge Based Learning
  - Formal Cooperative Learning
    - Instructor's Role
- Preparation for Afternoon Session
  - Reflect on your use of student teams
    - List things that are working well
    - List problems you've encountered

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Resources

- Design Framework – How People Learn (HPL) & Understanding by Design (UdB) Process
  - Bransford, John, Vye, Nancy, and Bateman, Helen. 2002. Creating High-Quality Learning Environments: Guidelines from Research on How People Learn. *The Knowledge Economy and Postsecondary Education: Report of a Workshop*. National Research Council. Committee on the Impact of the Changing Economy of the Education System. P.A. Graham and N.G. Stacey (Eds.). Center for Education. Washington, DC: National Academy Press. http://www.nap.edu/openbook/0309082927/html/
  - Mayer, R. E. 2010. *Applying the science of learning.* Upper Saddle River, NJ: Pearson.
  - Pellegrino – Rethinking and redesigning curriculum, instruction and assessment: What contemporary research and theory suggests. http://www.skillscommission.org/commissioned.htm
  - Smith, K. A., Douglas, T. C., & Cox, M. 2009. Supportive teaching and learning strategies in STEM education. In R. Baldwin, (Ed.). Improving the climate for undergraduate teaching in STEM fields. New Directions for Teaching and Learning, 117, 19-32. San Francisco: Jossey-Bass.
  - Wiggins, G. & McTighe, J. 2005. *Understanding by Design: Expanded Second Edition*. Prentice Hall.
- Content Resources
  - Donald, Janet. 2002. Learning to think: Disciplinary perspectives. San Francisco: Jossey-Bass.
  - Middendorf, Joan and Pace, David. 2004. Decoding the Disciplines: A Model for Helping Students Learn Disciplinary Ways of Thinking. New Directions for Teaching and Learning, 98.
- Cooperative Learning
  - Cooperative Learning (Johnson, Johnson & Smith) - Smith web site – www.ce.umn.edu/~smith
  - Smith (2010) Social nature of learning: From small groups to learning communities. New Directions for Teaching and Learning, 2010, 123, 11-22 [NDTL-123-2-Smith-Social_Basis_of_Learning-.pdf]
  - Smith, Sheppard, Johnson & Johnson (2005) Pedagogies of Engagement [Smith-Pedagogies_of_Engagement.pdf]
  - Johnson, Johnson & Smith. 1998. Cooperative learning returns to college: What evidence is there that it works? Change, 1998, 30 (4), 26-35. [CLReturnstoCollege.pdf]
- Other Resources
  - University of Delaware PBL web site – www.udel.edu/pbl
  - PKAL – Pedagogies of Engagement – http://www.pkal.org/activities/PedagogiesOfEngagementSummit.cfm
  - Fairweather (2008) Linking Evidence and Promising Practices in Science, Technology, Engineering, and Mathematics (STEM) Undergraduate Education http://www7.nationalacademies.org/bose/Fairweather_CommissionedPaper.pdf

Thank you!

An e-copy of this presentation is posted to:
http://www.ce.umn.edu/~smith/links.html

King Fahd University of Petroleum and Minerals – 26 August 2012

ksmith@umn.edu