Advancing Innovations in Higher Education

Karl A. Smith

STEM Education Center / Technological Leadership
Institute / Civil Engineering – University of Minnesota &
Engineering Education – Purdue University
ksmith@umn.edu - http://www.ce.umn.edu/~smith

University of Minnesota

Academy of Distinguished Teachers
2013 ADT Conference

October 4, 2013

Acknowledgements

- David & Roger Johnson – Cooperative Learning Center
- Civil Engineering, College of Science and Engineering
- Toni McNaron, Carol Miller & Carol Carrier – Bush Faculty Development Program for Excellence and Diversity in a Multicultural University (Early Career Teaching Program)
- Purdue University, College of Engineering, School of Engineering Education
- National Science Foundation
- David Langley (and Joyce Weinsheimer) – Center for Teaching and Learning & their many fabulous colleagues

Kathleen O'Donovan (1946-2013)

Reflection and Dialogue

- Individually reflect on Advancing Innovations in Higher Education. Think/Write for about 1 minute
  - Promising Innovations
  - Ideas for encouraging adoption by colleagues
- Discuss with your neighbor for about 2 minutes
  - How to propagate and scale education innovations

Teacher Mental Images About Teaching - Axelrod (1973)

Mental Image	Motto	Characteristics	Disciplines
Content	I teach what I know	Pour it in, Lecture	Science, Math
Instructor	I teach what I am	Modeling, Demonstration	Many
Student – Cognitive Development	I train minds	Active Learning, Discussion	English, Humanities
Student – Development of Whole Person	I work with students as people	Motivation, Self-esteem	Basic Skills Teachers

Axelrod, J. *The University Teacher as Artist.* San Francisco: Jossey-Bass, 1973.

6

Engineering Education: Advancing the Practice
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]
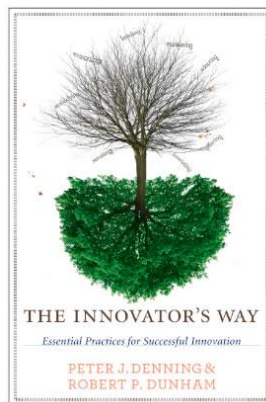
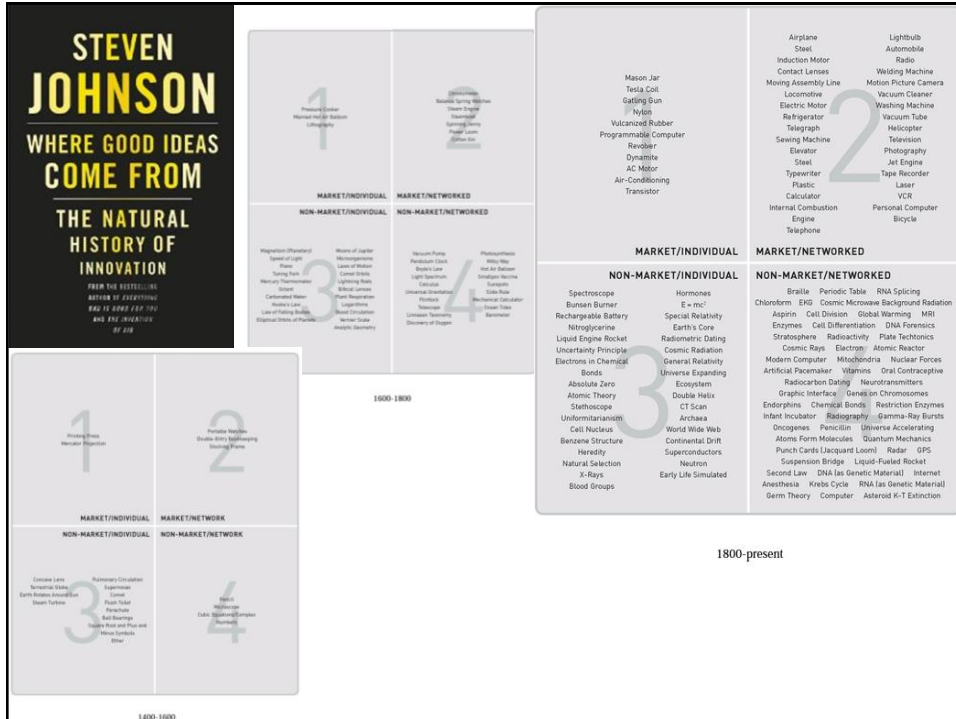Innovation is the adoption of a new practice in a community - Denning & Dunham (2010)

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

Undergraduate Teaching Faculty, 2011*

Methods Used in "All" or "Most"	STEM women	STEM men	All other women	All other men
Cooperative learning	60%	41%	72%	53%
Group projects	36%	27%	38%	29%
Grading on a curve	17%	31%	10%	16%
Student inquiry	43%	33%	54%	47%
Extensive lecturing	50%	70%	29%	44%

*Undergraduate Teaching Faculty. National Norms for the
2010-2011 HERI Faculty Survey, www.heri.ucla.edu/index.php

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
http://learningcommons.evergreen.edu/pdf/fall1987.pdf
12

Process Metallurgy

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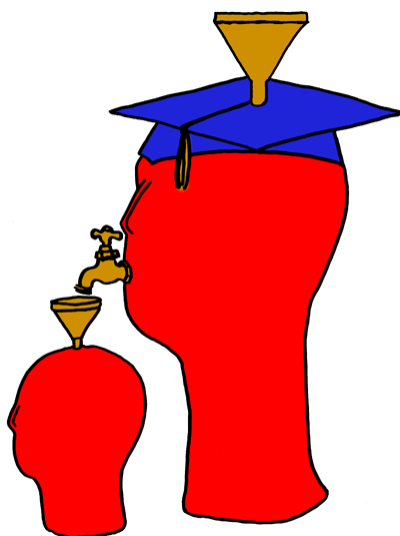
Dissolution Kinetics

- Theory – Governing Equation for Mass Transport
- Research – rotating disk
- Practice – leaching of silver bearing metallic copper & printed circuit-board waste

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

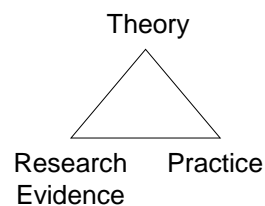$$v_y \frac{dc}{dy} = D\frac{d^2 c}{dy^2}$$
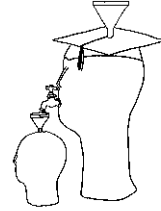
First Teaching Experience

- 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 – ?

Theory

Research
Evidence

Practice

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

Lila M. Smith
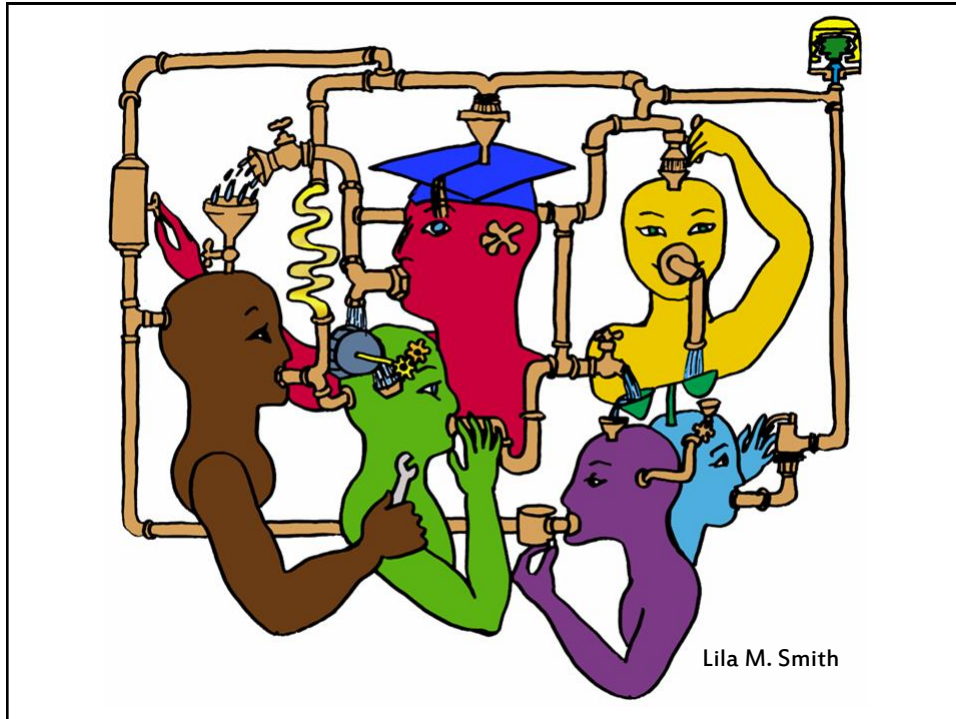
Cooperative Learning

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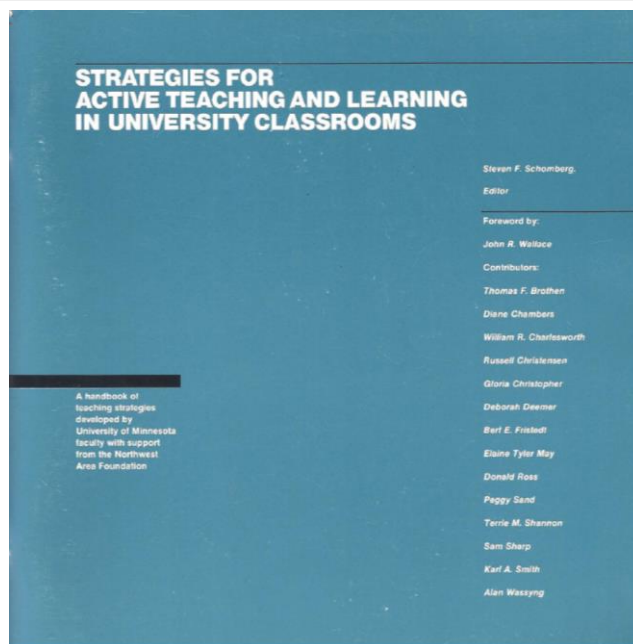
Theory

Research Evidence   Practice
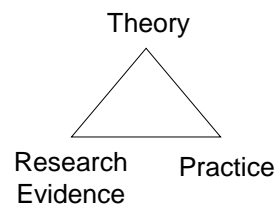
Cooperative Learning Introduced to Engineering – 1981

- Smith, K.A., Johnson, D.W. and Johnson, R.T., 1981. The use of cooperative learning groups in engineering education. In L.P. Grayson and J.M. Biedenbach (Eds.), *Proceedings Eleventh Annual Frontiers in Education Conference*, Rapid City, SD, Washington: IEEE/ASEE, 26-32.

21

JEE December 1981

22

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
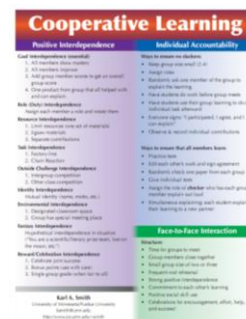6. Liking for subject areas
7. Teamwork skills
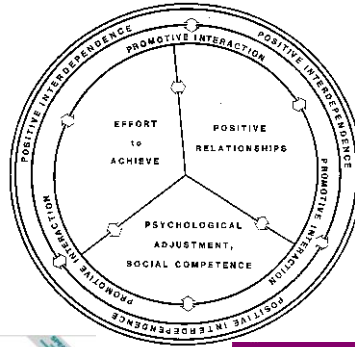
January 2005   March 2007

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

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

Slide 1

Pedagogies of Engagement: Classroom-Based Practices

KARL A. SMITH
*Department of Civil Engineering
University of Minnesota*

SHERI D. SHEPPARD
*Department of Mechanical Engineering
Stanford University*

DAVID W. JOHNSON
*Department of Educational Psychology
University of Minnesota*

ROGER T. JOHNSON
*Department of Curriculum and Instruction
University of Minnesota*

"Throughout the whole enterprise, the core issue, in my view, is the mode of teaching and learning that is practiced. Learning 'about' things does not enable students to acquire the abilities and understanding they will need for the twenty-first century. We need new **pedagogies of engagement** that will turn out the kinds of resourceful, engaged workers and citizens that America now requires."

Russ Edgerton (reflecting on higher education projects funded by the Pew Memorial Trust)

25

http://www.asee.org/publications/jee/issueList.cfm?year=2005#January2005

Slide 2

Pedagogies of Engagement

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

27

Fundamentals of Engineering Education Research

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

Faculty Development Workshop (2013) – January 9, 2013 – Jeju Island, South Korea

Ruth A.Streveler
Purdue University

Karl A. Smith
Purdue University and
University of Minnesota

Discipline-Based Education Research: Findings and Implications

King Fahd University of Petroleum and Minerals – August 19, 2013 – Saudi Arabia

Karl A. Smith
Purdue University and
University of Minnesota

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.

Discipline-Based Education Research (DBER)

Understanding and Improving
Learning in Undergraduate Science
and Engineering

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

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.

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

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

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

---

*"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

Course Design Foundations

Science of Instruction (UbD)

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

Science of Learning (HPL)
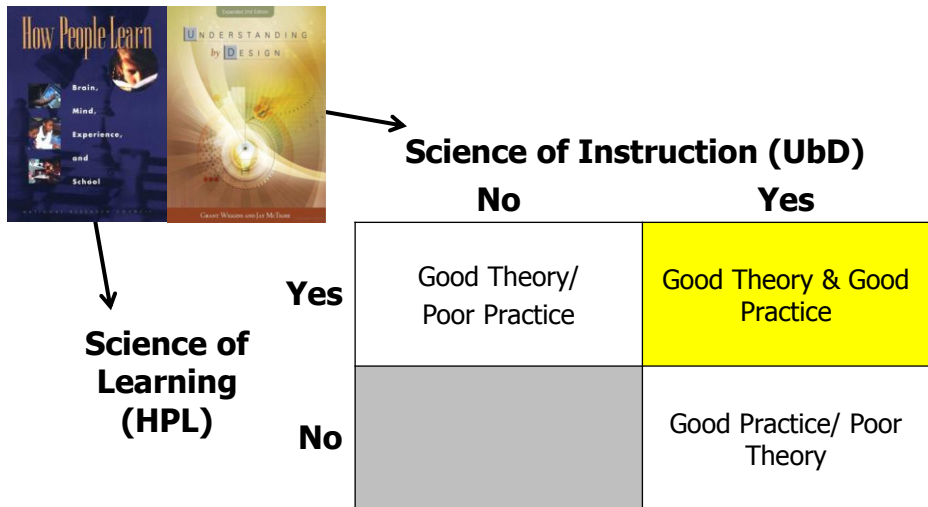
Bransford, Brown & Cocking. 1999. *How People Learn.* National Academy Press.
Wiggins & McTighe, 2005. *Understanding by Design, 2ed.* ASCD.

How People Learn (HPL)

HPL Framework
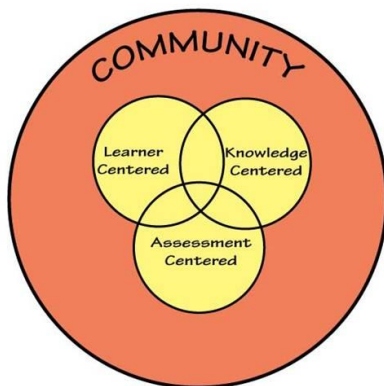
- Expertise implies (Ch. 2):
  - a set of cognitive and metacognitive skills
  - an organized body of knowledge that is deep and contextualized
  - an ability to notice patterns of information in a new situation
  - flexibility in retrieving and applying that knowledge to a new problem

Bransford, Brown & Cocking. 1999. *How people learn.* National Academy Press.

Understanding by Design

- Stage 1. Identify Desired Results
  - Enduring understanding (enduring outcomes)
  - 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?

Wiggins & McTighe, 1997, 2005. *Understanding by Design.* Alexandria, VA: ASCD.

•Bransford, Vye and Bateman – Creating High Quality Learning Environments
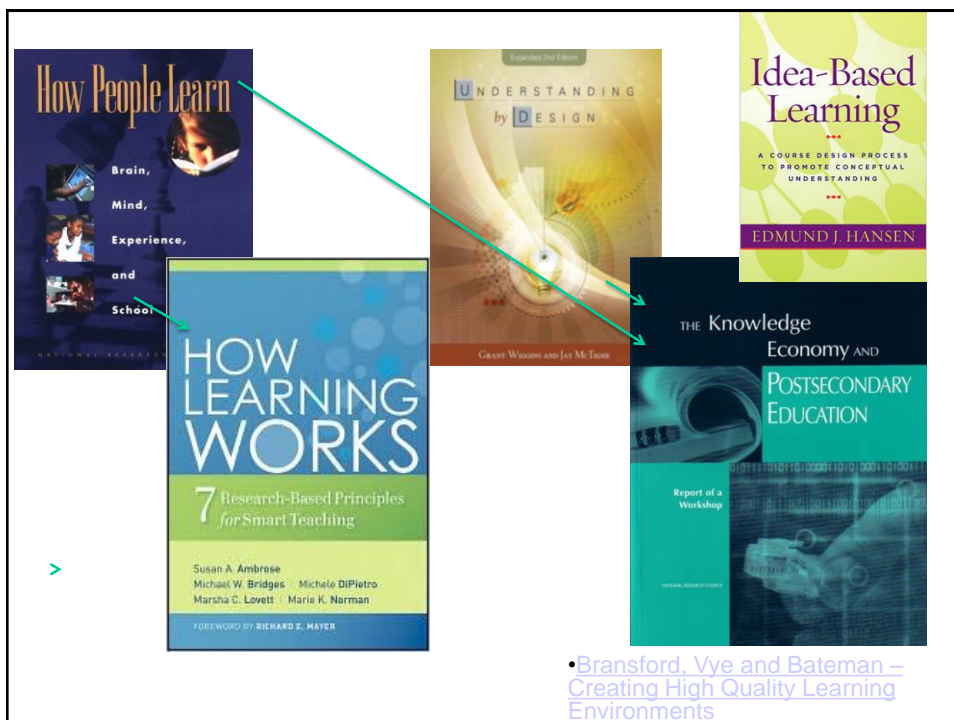
Revised Bloom's Learning Taxonomy

Source: http://www.celt.iastate.edu/pdfs-docs/teaching/RevisedBloomsHandout.pdf

Interactive Learning Continuum

Make the lecture active

Informal Group Activities

Structured Team Activities

Problems Drive the Course

Instructor Centered

Student Centered

Active Learning

Collaborative Learning

Formal Cooperative Learning

Problem-Based Learning
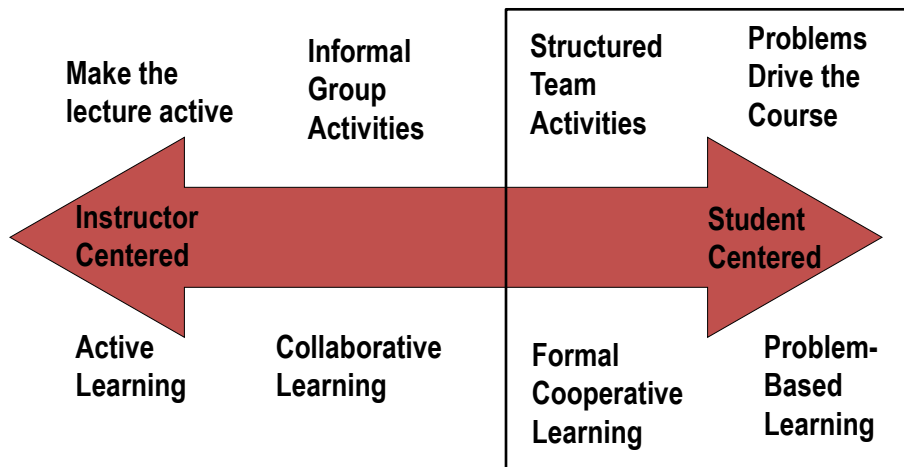
Strong Evidence Base – Cooperative Learning & Challenge-Based Learning

Prince, M. (2010). NAE FOEE

Informal Cooperative Learning

January 2, 2009—Science, Vol. 323 – www.sciencemag.org

Calls for evidence-based instruction practices

Active Learning: Cooperation in the College Classroom

- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups
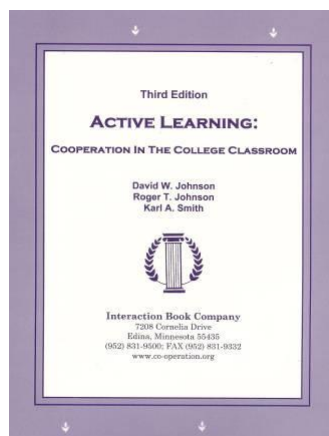
See Cooperative Learning Handout (CL College-912.doc)

42

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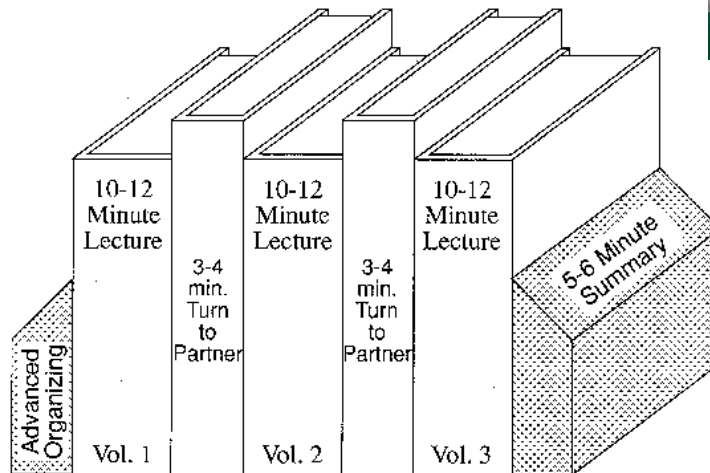
Smith, K.A. 2000. Going deeper: Formal small-group learning in large classes. Energizing large classes: From small groups to learning communities. *New Directions for Teaching and Learning*, 2000, 81, 25-46. [NDTL81Ch3GoingDeeper.pdf]

43

Book Ends on a Class Session

1. Advance Organizer
2. Formulate-Share-Listen-Create (Turn-to-your-neighbor) -- repeated every 10-12 minutes
3. Session Summary (Minute Paper)
   1. What was the most useful or meaningful thing you learned during this session?
   2. What question(s) remain uppermost in your mind as we end this session?
   3. What was the "muddiest" point in this session?

Formulate-Share-Listen-Create

Informal Cooperative Learning Group
Introductory Pair Discussion of a

FOCUS QUESTION

1. Formulate your response to the question **individually**
2. Share your answer with a partner
3. Listen carefully to your partner's answer
4. Work together to Create a new answer through discussion

45

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/   46

University of Minnesota Collaborative Model
for Large Introductory Courses

http://groups.physics.umn.edu/physed/Research/MNModel/Model.html
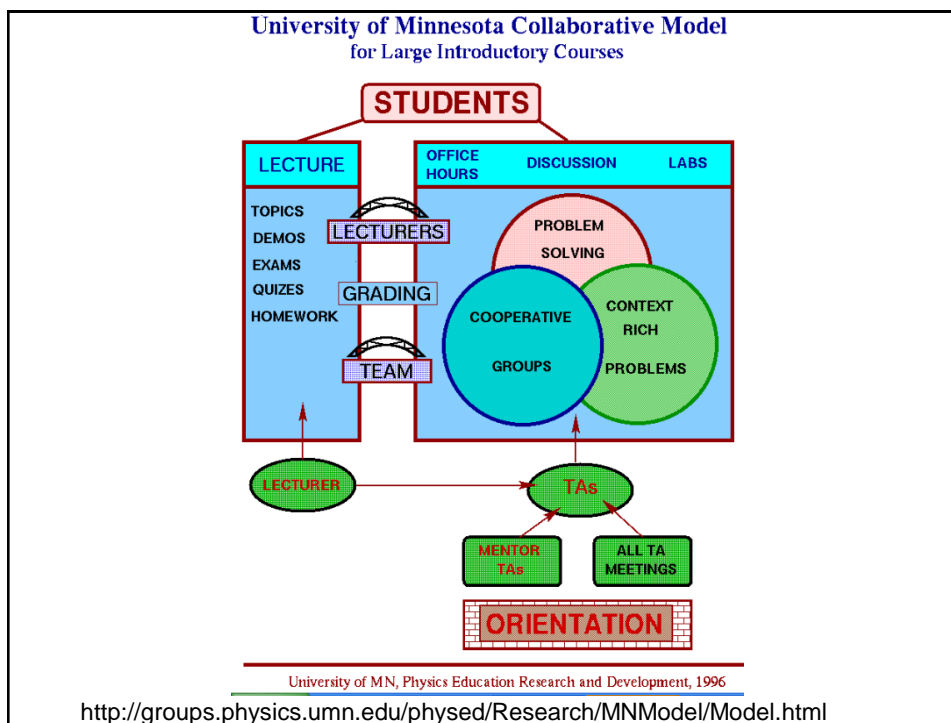
Conceptual Understanding

University of Minnesota FCI Scores

http://groups.physics.umn.edu/physed/Research/MNModel/FCI.html
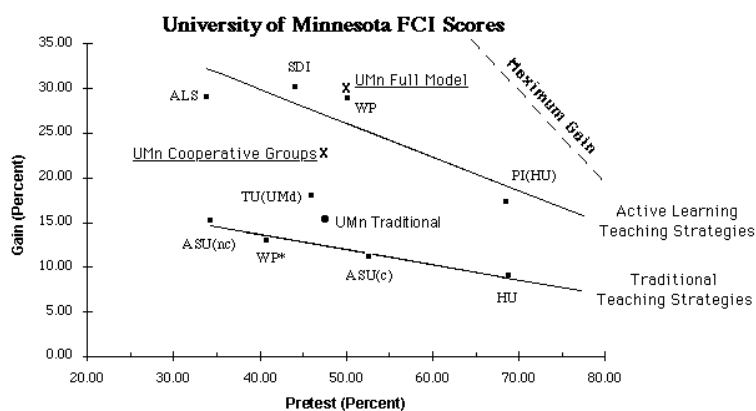
Physics (Mechanics) Concepts:
The Force Concept Inventory (FCI)

- A 30 item multiple choice test to probe student's understanding of basic concepts in mechanics.
- The choice of topics is based on careful thought about what the fundamental issues and concepts are in Newtonian dynamics.
- Uses common speech rather than cueing specific physics principles.
- The distractors (wrong answers) are based on students' common inferences.

49

Workshop Biology

Traditional passive lecture vs. "Workshop biology"
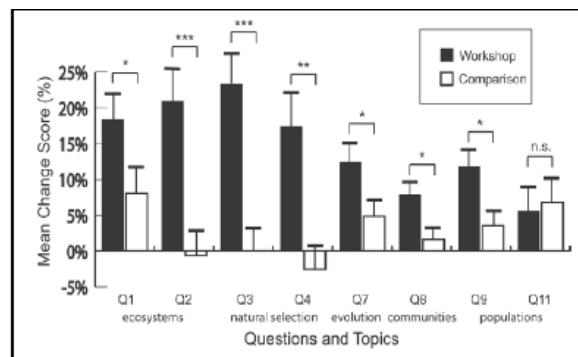
Source: Udovic et al. 2002

Biology
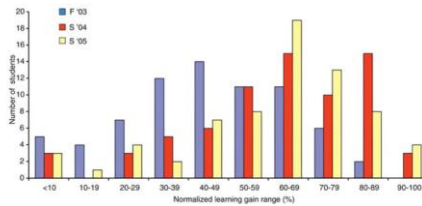
Figure 3. Comparison of normalized learning gains (% of possible maximum) in 10% increments on 12 common pretest and posttest questions for students in one traditional (F'03) and two interactive (S'04, S'05) classes. Normalized learning gains were computed as in Figure 2.

Table 4. Comparison of average performance on different assessments for all three courses

Assessment	of maximum score)		
	F'03	S'04	S'05
Pretest (12 questions)[a]	34	31	37
posttest (12 questions)[a]	65	74	72
Raw learning gain	31	43	38
Normalized learning gain[b]	46	62	61
Hourly exams	71	71	73
Final exam	77	71	76
Problem sets	82	85	90
Participation	N/A	86	86
Final total points	76	81	81

[a] Data based only on the 12 questions that were common to all three pretests and posttests (see Appendix A).
[b] Average for each class is shown. Normalized learning gains were computed as described in the text and the legend to Figure 2.

Source: Knight, J. and Wood, W. (2005). Teaching more by lecturing less. *Cell Biol Educ.* 4(4): 298–310.

Informal Cooperative Learning Groups
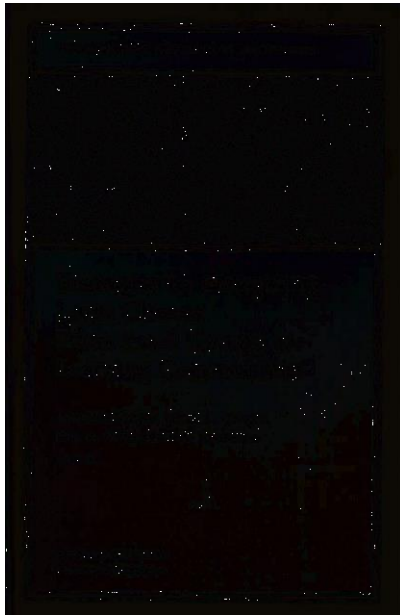
Can be used at any time
Can be short term and ad hoc
May be used to break up a long lecture
Provides an opportunity for students to process material they have been listening to (Cognitive Rehearsal)
Are especially effective in large lectures
Include "book ends" procedure
Are not as effective as Formal Cooperative Learning or Cooperative Base Groups

Strategies for Energizing Large Classes: From Small Groups to Learning Communities:

Jean MacGregor,
James Cooper,
Karl Smith,
Pamela Robinson

New Directions for Teaching and Learning,
No. *81*, 2000.
Jossey- Bass

Informal Cooperative Learning Planning Form

DESCRIPTION OF THE LECTURE

1. Lecture Topic: _____

2. Objectives (Major Understandings Students Need To Have At The End Of The Lecture):

   a. _____

   b. _____

3. Time Needed: _____

4. Method For Assigning Students To Pairs Or Triads: _____

5. Method Of Changing Partners Quickly: _____

6. Materials (such as transparencies listing the questions to be discussed and describing the **formulate, share, listen, create** procedure): _____

ADVANCED ORGANIZER QUESTION(S)

Questions should be aimed at promoting **advance organizing** of what the students know about the topic to be presented and **establishing expectations** as to what the lecture will cover.

1. _____
2. _____
3. _____

COGNITIVE REHEARSAL QUESTIONS

List the specific questions to be asked every 10 or 15 minutes to ensure that participants understand and process the information being presented. Instruct students to use the **formulate, share, listen, and create** procedure.

1. _____
2. _____
3. _____
4. _____

Monitor by systematically observing each pair. Intervene when it is necessary. Collect data for whole class processing. Students' explanations to each other provide a window into their minds that allows you to see what they do and do not understand. Monitoring also provides an opportunity for you to get to know your students better.

SUMMARY QUESTION(S)

Give an ending discussion task and require students to come to consensus, write down the pair or triad's answer(s), sign the paper, and hand it in. Signatures indicate that students agree with the answer, can explain it, and guarantee that their partner(s) can explain it. The questions could (a) ask for a summary, elaboration, or extension of the material presented or (b) precue the next class session.

1. _____
2. _____

CELEBRATE STUDENTS' HARD WORK

1. _____
2. _____

54

Active Learning: Cooperation in the College Classroom

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

Third Edition

ACTIVE LEARNING:

COOPERATION IN THE COLLEGE CLASSROOM

David W. Johnson
Roger T. Johnson
Karl A. Smith

Interaction Book Company
7208 Cornelia Drive
Edina, Minnesota 55435
(952) 831-9500; FAX (952) 831-9332
www.co-operation.org
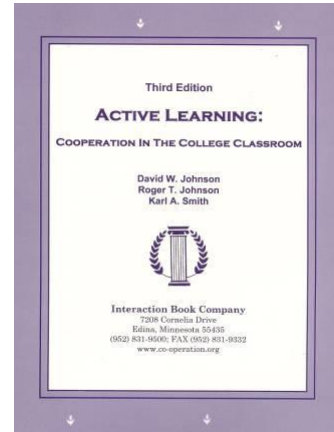
See Cooperative Learning
Handout (CL College-912.doc)   55

Formal Cooperative Learning Task Groups

Design team failure is usually due to failed team dynamics
(Leifer, Koseff & Lenshow, 1995).

It's the soft stuff that's hard, the hard stuff is easy
(Doug Wilde, quoted in Leifer, 1997)
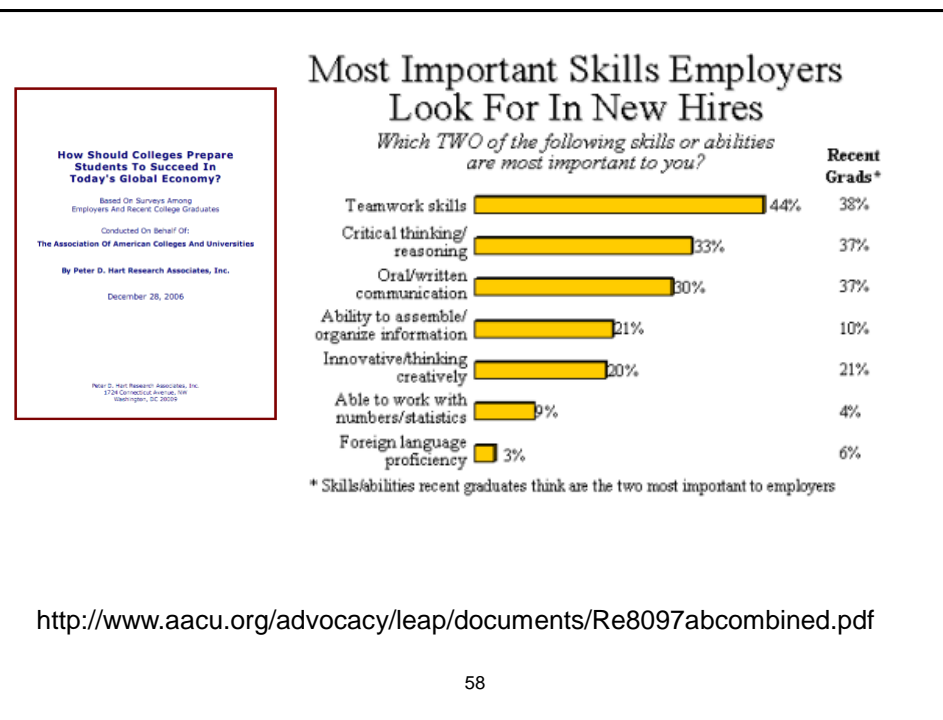
Professional Skills
(Shuman, L., Besterfield-Sacre, M., and McGourty, J., "The ABET Professional Skills-Can They Be Taught? Can They Be Assessed?" Journal of Engineering Education, Vo. 94, No. 1, 2005, pp. 41–55.)

Most Important Skills Employers Look For In New Hires

Which TWO of the following skills or abilities are most important to you?

Skill	Employers	Recent Grads*
Teamwork skills	44%	38%
Critical thinking/reasoning	33%	37%
Oral/written communication	30%	37%
Ability to assemble/organize information	21%	10%
Innovative/thinking creatively	20%	21%
Able to work with numbers/statistics	9%	4%
Foreign language proficiency	3%	6%

* Skills/abilities recent graduates think are the two most important to employers

How Should Colleges Prepare Students To Succeed In Today's Global Economy?

Based On Surveys Among Employers And Recent College Graduates

Conducted On Behalf Of:
The Association Of American Colleges And Universities

By Peter D. Hart Research Associates, Inc.

December 28, 2006

Peter D. Hart Research Associates, Inc.
1724 Connecticut Avenue, NW
Washington, DC 20009

http://www.aacu.org/advocacy/leap/documents/Re8097abcombined.pdf

58

Top Three Main Engineering Work Activities

Engineering Total

- Design – 36%
- Computer applications – 31%
- Management – 29%

Burton, L., Parker, L, & LeBold, W. 1998. U.S. engineering career trends. *ASEE Prism*, *7*(9), 18-21.

Civil/Architectural

- Management – 45%
- Design – 39%
- Computer applications – 20%

59

Teamwork
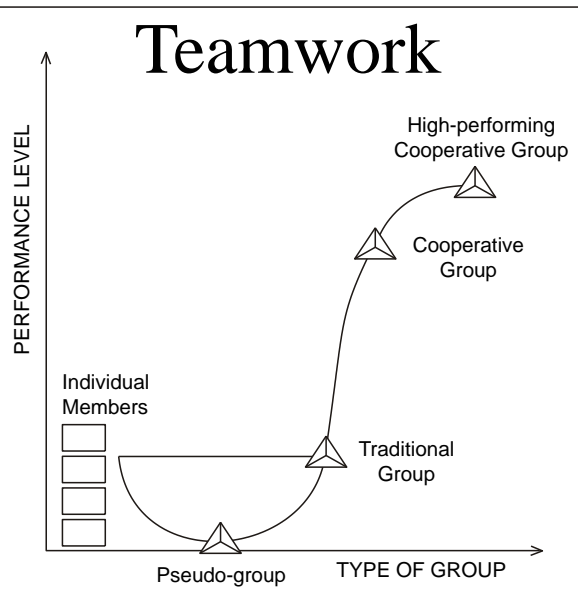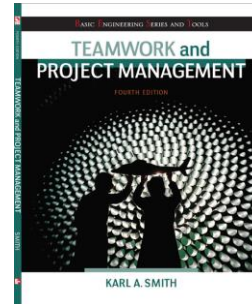
60

Characteristics of Effective Teams?

• ?

•?

61

A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable

• SMALL NUMBER

• COMPLEMENTARY SKILLS

• COMMON PURPOSE & PERFORMANCE GOALS

• COMMON APPROACH

• MUTUAL ACCOUNTABILITY

--Katzenbach & Smith (1993)
The Wisdom of Teams

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

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

---
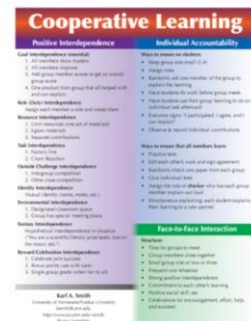
Teamwork Skills

- Communication
  - Listening and Persuading
- Decision Making
- Conflict Management
- Leadership
- Trust and Loyalty

Instructor'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

65

Decisions,Decisions

Group size?
Group selection?
Group member roles?
How long to leave groups together?
Arranging the room?
Providing materials?
Time allocation?

66

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
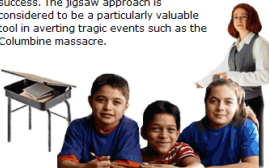
6. Constructive Controversy

7. **Group Tests**

Cooperative Jigsaw

Jigsaw Classroom

Welcome to the official web site of the jigsaw classroom, a cooperative learning technique that reduces racial conflict among school children, promotes better learning, improves student motivation, and increases enjoyment of the learning experience. The jigsaw technique was first developed in the early 1970s by Elliot Aronson and his students at the University of Texas and the University of California. Since then, hundreds of schools have used the jigsaw classroom with great success. The jigsaw approach is considered to be a particularly valuable tool in averting tragic events such as the Columbine massacre.

Explore the Jigsaw Classroom:
- Overview of the Technique
- History of the Jigsaw Classroom
- Jigsaw in 10 Easy Steps
- Tips on Implementation
- Books and Articles Related to the Jigsaw Technique
- Chapter 1 of Aronson's Book "Nobody Left to Hate: Teaching Compassion After Columbine"
- Links on Cooperative Learning and School Violence
- About Elliot Aronson and This Web Site

Content © 2000-2013, Elliot Aronson
Web Site © 2000-2013, Social Psychology Network

Site Statistics
Deutsche Übersetzung

www.jigsaw.org/

JIGSAW SCHEDULE

COOPERATIVE GROUPS (3-4 members)

PREPARATION PAIRS

CONSULTING/SHARING PAIRS

TEACHING/LEARNING IN COOPERATIVE GROUPS

WHOLE CLASS REVIEW

68

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 Controversy

7. **Group Tests**

Problem Based Cooperative Learning Format

TASK: Solve the problem(s) or Complete the project.

INDIVIDUAL: Develop ideas, Initial Model, Estimate, etc. Note strategy.

COOPERATIVE: One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to solve each problem.

EXPECTED CRITERIA FOR SUCCESS: Everyone must be able to explain the model and strategies used to solve each problem.

EVALUATION: Best answer within available resources or constraints.

INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) the answer and (b) how to solve each problem.

EXPECTED BEHAVIORS: Active participating, checking, encouraging, and elaborating by all members.

INTERGROUP COOPERATION: Whenever it is helpful, check procedures, answers, and strategies with another group.
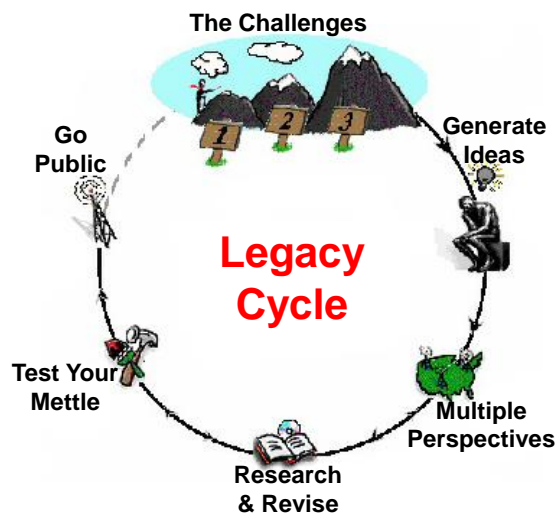
70

Challenge-Based Learning

- Problem-based learning
- Case-based learning
- Project-based learning
- Learning by design
- Inquiry learning
- Anchored instruction

John Bransford, Nancy Vye and Helen Bateman. Creating High-Quality Learning Environments: Guidelines from Research on How People Learn
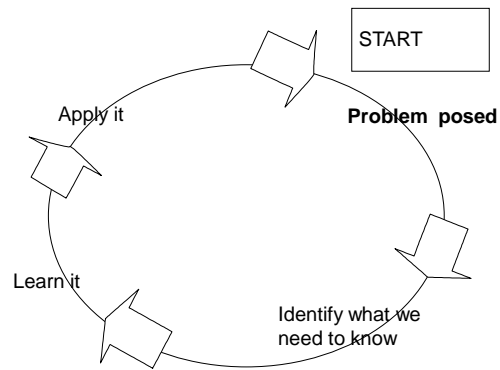
71

Challenge-Based Instruction with the Legacy Cycle

https://repo.vanth.org/portal/public-content/star-legacy-cycle/star-legacy-cycle

72

Problem-Based Learning

START

Problem posed

Apply it

Identify what we
need to know

Learn it

73

Problem-Based Cooperative Learning

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

Josh Hitun 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

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,

COMMENTS (00)
E-MAIL
PRINT
SINGLE PAGE

74

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

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

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

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

77

Inside an Active Learning Classroom

- STSS at the University of Minnesota

http://vimeo.com/andyub/activeclassroom

"I love this space! It makes me feel appreciated as a student, and I feel intellectually invigorated when I work and learn in it."

http://tile.uiowa.edu/   79

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

Active Learning: Cooperation in the College Classroom

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

Third Edition

ACTIVE LEARNING:

COOPERATION IN THE COLLEGE CLASSROOM

David W. Johnson
Roger T. Johnson
Karl A. Smith

Interaction Book Company
7208 Cornelia Drive
Edina, Minnesota 55435
(952) 831-9500; FAX (952) 831-9332
www.co-operation.org

See Cooperative Learning
Handout (CL College-912.doc)   81

Cooperative Base Groups

- Are Heterogeneous
- Are Long Term (at least one quarter or semester)
- Are Small (3-5 members)
- Are for support
- May meet at the beginning of each session or may meet between sessions
- Review for quizzes, tests, etc. together
- Share resources, references, etc. for individual projects
- Provide a means for covering for absentees

82

Does Psychological Safety Hinder Performance?

Psychological safety does not operate at the expense of employee accountability; the most effective organizations achieve high levels of both, as this matrix shows.

Accountability for Meeting Demanding Goals

Psychological Safety	LOW	HIGH
HIGH	**Comfort zone** — Employees really enjoy working with one another but don't feel particularly challenged. Nor do they work very hard. Some family businesses and small consultancies fall into this quadrant.	**Learning zone** — Here the focus is on collaboration and learning in the service of high-performance outcomes. The hospitals described in this article fall into this quadrant.
LOW	**Apathy zone** — Employees tend to be apathetic and spend their time jockeying for position. Typical organizations in this quadrant are large, top-heavy bureaucracies, where people fulfill their functions but the preferred modus operandi is to curry favor rather than to share ideas.	**Anxiety zone** — Such firms are breeding grounds for anxiety. People fear to offer tentative ideas, try new things, or ask colleagues for help, even though they know great work requires all three. Some investment banks and high-powered consultancies fall into this quadrant.

Edmonson-Competitive_Advantage_of_Learning-HBR-2008.pdf

Accountability for Meeting Demanding Goals

Psychological Safety	LOW	HIGH
HIGH	**Comfort zone** — Employees really enjoy working with one another but don't feel particularly challenged. Nor do they work very hard. Some family businesses and small consultancies fall into this quadrant.	**Learning zone** — Here the focus is on collaboration and learning in the service of high-performance outcomes. The hospitals described in this article fall into this quadrant.
LOW	**Apathy zone** — Employees tend to be apathetic and spend their time jockeying for position. Typical organizations in this quadrant are large, top-heavy bureaucracies, where people fulfill their functions but the preferred modus operandi is to curry favor rather than to share ideas.	**Anxiety zone** — Such firms are breeding grounds for anxiety. People fear to offer tentative ideas, try new things, or ask colleagues for help, even though they know great work requires all three. Some investment banks and high-powered consultancies fall into this quadrant.

Edmonson-Competitive_Advantage_of_Learning-HBR-2008.pdf

Designing and Implementing Cooperative Learning

- Think like a designer
- Ground practice in robust theoretical framework
- Start small, start early and iterate
- Celebrate the successes; problem-solve the failures

Global Calls for Reform

K-12 Engineering

Research-based Transformation
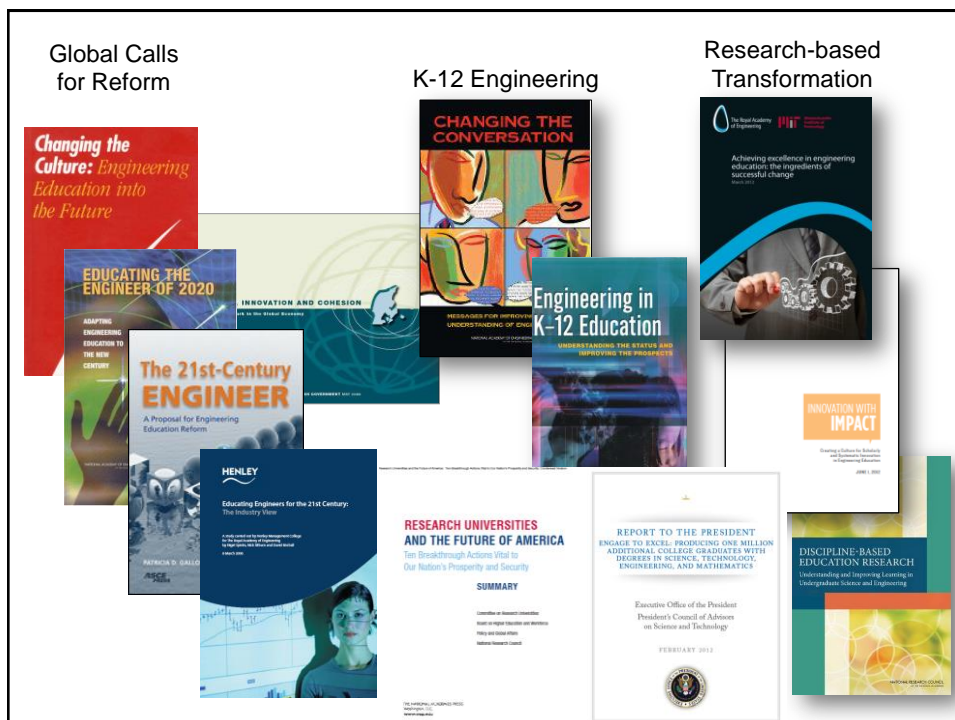
Discipline-Based Education Research (DBER)

National Research
Council
2012

- Discipline-based education research (DBER) is a **small but growing field of inquiry**.
- **Conducting DBER** and **using DBER** findings are **distinct but interdependent** pursuits.
- DBER is **inherently interdisciplinary.**
- Individual fields of DBER have made **notable inroads** in terms of establishing their fields **but still face challenges in doing so**.
- **Blending** a scientific/engineering discipline with education research poses **unique professional challenges for DBER scholars**.
- There are **many pathways to becoming a discipline-based education researcher**.

Discipline-Based Education Research Timeline

National Research
Council
2012

Engr. Sci. Reform	EC2000 → **EER**
Curricula Reform	Geoscience
	Biology ER
Curricula Reform →	Chemistry ER
Curricula Reform →	Physics ER
Medical ER	

| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 |
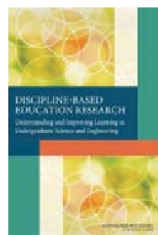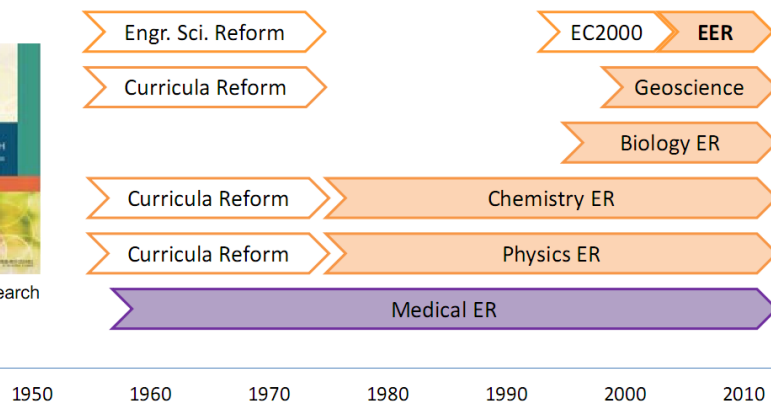
DBER is **located** in the relevant disciplinary school, e.g. medicine, physics.

Discipline-Based Education Research (DBER) Report Update

ASEE *Prism Summer 2013*

Discipline-Based
Education Research

Practitioner Guide

In Preparation
Coming 2014

National Research Council
Summer 2012 – http://www.nap.edu/
catalog.php?record_id=13362

Journal of Engineering Education
Editorial – October, 2013

Workshop: I-Corps for Learning (I-Corps-L):
*A Pilot Initiative to Propagate & Scale
Educational Innovations*
(NSF DUE)

1. Give the I-Corps-L team an experiential learning opportunity to help determine the readiness of their innovation for sustainable scalability. Sustainable scalability involves a self-supported entity that is sustainable and systematically promotes the adoption of the educational innovation and enables and facilitates its use.

2. Enable the team to develop a clear go/no go decision regarding sustainable scalability of the innovation.

3. Develop a transition plan and actionable tasks to move the innovation forward to sustainable scalability, if the team decides to do so.

Instructor Team: Karl Smith (PI), Ann McKenna & Chris Swan

Education Innovation

- Stories supported by evidence are essential for adoption of new practices
  - Good ideas and/or insightful connections
  - Supported by evidence
  - Spread the word
  - Patience and persistence
- Cooperative learning took over 25 years to become widely practiced in higher education
- **We can't wait 25 years for YOUR innovations to become widely practiced!**

91

The Instructor's Role in Cooperative Learning

Make Pre-Instructional Decisions

Specify Academic and Teamwork Skills Objectives: Every lesson has both (a) academic and (b) interpersonal and small group (teamwork) skills objectives.

Decide on Group Size: Learning groups should be small (groups of two or three members, four at the most).

Decide on Group Composition (Assign Students to Groups): Assign students to groups randomly or select groups yourself. Usually you will wish to maximize the heterogeneity in each group.

Assign Roles: Structure student-student interaction by assigning roles such as Reader, Recorder, Encourager of Participation and Checker for Understanding.

Arrange the Room: Group members should be "knee to knee and eye to eye" but arranged so they all can see the instructor at the front of the room.

Plan Materials: Arrange materials to give a "sink or swim together" message. Give only one paper to the group or give each member part of the material to be learned.

Explain Task And Cooperative Structure

Explain the Academic Task: Explain the task, the objectives of the lesson, the concepts and principles students need to know to complete the assignment and the procedures they are to follow.

Explain the Criteria for Success: Student work should be evaluated on a criteria-referenced basis. Make clear your criteria for evaluating students' work.

*Structure Positive Interdependence: Students must believe they "sink or swim together." Always establish mutual goals (students are responsible for their own learning and the learning of all other group members). Supplement, goal interdependence with celebration reward, resource, role, and identity interdependence.

Structure Intergroup Cooperation: Have groups check with and help other groups. Extend the benefits of cooperation to the whole class.

*Structure Individual Accountability: Each student must feel responsible for doing his or her share of the work and helping the other group members. Ways to ensure accountability are frequent oral quizzes of group members picked at random, individual tests, and assigning a member the role of Checker for Understanding.

*Specify Expected Behavior: The more specific you are about the behaviors you want to see in the groups, the more likely students will do them. Social skills may be classified as **forming** (staying with the group, using quiet voices), **functioning** (contributing, encouraging others to participate), **formulating** (summarizing, elaborating), and **fermenting** (criticizing ideas, asking for justification). Regularly teach the interpersonal and small group skills you wish to see used in the learning groups.

Monitor and Intervene

*Arrange Face-to-Face Promotive Interaction: Conduct the lesson in ways that ensure that students promote each other's success face-to-face.

Monitor Students' Behavior: This is the fun part! While students are working, you circulate to see whether they understand the assignment and the material, give immediate feedback and reinforcement, and praise good use of group skills. Collect observation data on each group and student.

Intervene to Improve Taskwork and Teamwork: Provide taskwork assistance (clarify, reteach) if students do not understand the assignment. Provide teamwork assistance if students are having difficulties in working together productively.

Evaluate and Process

Evaluate Student Learning: Assess and evaluate the quality and quantity of student learning. Involve students in the assessment process.

*Process Group Functioning: Ensure each student receives feedback, analyzes the data on group functioning, sets an improvement goal, and participates in a team celebration. Have groups routinely list three things they did well in working together an done thing they will do better tomorrow. Summarize as a whole class. Have groups celebrate their success and hard work.

92

Cooperative Lesson Planning Form

Subject Area: _____ Date: _____

Lesson: _____

Objectives

Academic: _____

Social Skills: _____

Preinstructional Decisions

Group Size: _____ Method Of Assigning Students: _____

Roles: _____

Room Arrangement: _____

Materials: _____

◊ One Copy Per Group   ◊ One Copy Per Person

◊ Jigsaw   ◊ Tournament

◊ Other: _____

Explain Task And Cooperative Goal Structure

1. Task: _____

2. Criteria For Success: _____

3. Positive Interdependence: _____

4. Individual Accountability: _____

5. Intergroup Cooperation: _____

6. Expected Behaviors: _____

Monitoring And Intervening

1. Observation Procedure: _____ Formal _____ Informal

2. Observation By: _____ Teacher _____ Students _____ Visitors

3. Intervening For Task Assistance: _____

4. Intervening For Teamwork Assistance: _____

5. Other: _____

Evaluating And Processing

1. Assessment Of Members' Individual Learning: _____

2. Assessment Of Group Productivity: _____

3. Small Group Processing: _____

4. Whole Class Processing: _____

5. Charts And Graphs Used: _____

6. Positive Feedback To Each Student: _____

7. Goal Setting For Improvement: _____

8. Celebration: _____

9. Other: _____

93

Resources

- Design Framework – How People Learn (HPL) & Understanding by Design (UdB) Process
  - Ambrose, S., et.al. 2010. *How learning works: 7 research based principles for smart* teaching. Jossey-Bass
  - 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/
  - Pellegrino, J. 2006. 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.
  - Streveler, R.A., Smith, K.A. and Pilotte, M. 2012. Content, Assessment and Pedagogy (CAP): An Integrated Engineering Design Approach. In Dr. Khairiyah Mohd Yusof, Dr. Shahrin Mohammad, Dr. Naziha Ahmad Azli, Dr. Mohamed Noor Hassan, Dr. Azlina Kosnin and Dr. Sharifah Kamilah Syed Yusof (Eds.). *Outcome-Based Education and Engineering Curriculum: Evaluation, Assessment and Accreditation*, Universiti Teknologi Malaysia, Malaysia [Streveler-Smith-Pilotte_OBE_Chapter-CAP-v11.pdf]
  - 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

Reflection and Dialogue

- Individually reflect on your Education Innovation. Write for about 1 minute
  - Are the student learning outcomes clearly articulated?
    - Are they BIG ideas at the heart of the discipline?
  - Are the assessments aligned with the outcomes?
  - Is the pedagogy aligned with the outcomes & assessment?
- Discuss with your neighbor for about 2 minutes
  - Select Design Example, Comment, Insight, etc. that you would like to present to the whole group if you are randomly selected