Design and Implementation of Pedagogies of Engagement (Cooperative Learning and Problem-Based Learning)

Karl A. Smith
STEM Education Center / Technological Leadership Institute / Civil Engineering – University of Minnesota & Engineering Education – Purdue University
ksmith@umn.edu
http://personal.cege.umn.edu/~smith/links.html

University of New Haven

March 6, 2015

Session Layout

- Welcome & Overview
- Evidence-Based Practices
  - Rationale
- Course Design Foundations
  - How Learning Works
  - How People Learn
  - Understanding by Design
- Pedagogies of Engagement: Cooperative Learning & Challenge-Based Learning
  - Rationale
  - Key Elements
- Applications of Pedagogies of Engagement

2

Overall Goal

- How to design courses to increase student engagement (David Harding, 2/12/15)
- Build your knowledge of Evidence-Based Practices and your implementation repertoire

3

Workshop Objectives

- Participants will be able to :
  - Describe key features of evidence-based instruction and effective, interactive strategies for facilitating learning
  - Summarize key elements of Course Design Foundations
    - *How Learning Works* and *How People Learn (HPL)*
    - *Understanding by Design* (UbD) process – Content (outcomes) – Assessment – Pedagogy
  - Explain key features of and rationale for Pedagogies of Engagement – Cooperative Learning and Challenge-Based learning
  - Identify connections between cooperative learning and desired outcomes of courses and programs
- Participants will begin applying key elements to the design on a course, class session or learning module

4

Reflection and Dialogue

- Individually reflect on your favorite **rationale** for Engaging Students. Write for about 1 minute
  - Context/Audience? E.g., First Year Engineering
  - Claim? What is the nature of the rationale?
  - Evidence? Support for your claim
- Discuss with your neighbor for about 2 minutes
  - Select/create a response to present to the whole group if you are randomly selected

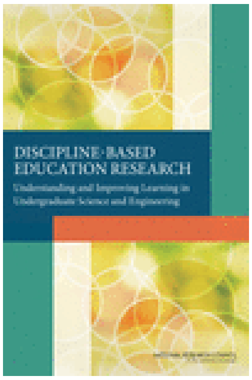
Seven Principles for Good Practice in Undergraduate Education

- 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

6

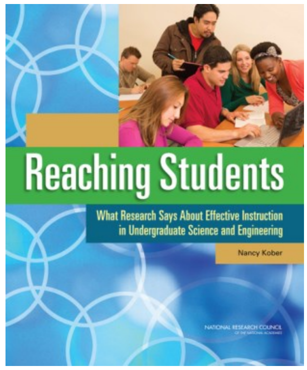
Discipline-Based Education Research (DBER) Report




LAST WORD

Follow the Evidence

STUDENTS ARE CHALLENGED BY KEY ASPECTS OF ENGINEERING AND SCIENCE THAT CAN SEEM EASY OR OBVIOUS TO EXPERTS.



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

ASEE *Prism Summer 2013*

Journal of Engineering Education – October, 2013

National Research Council – 2015 http://www.nap.edu/catalog/18687/reaching-students-what-research-says-about-effective-instruction-in-undergraduate

Student Engagement Research Evidence

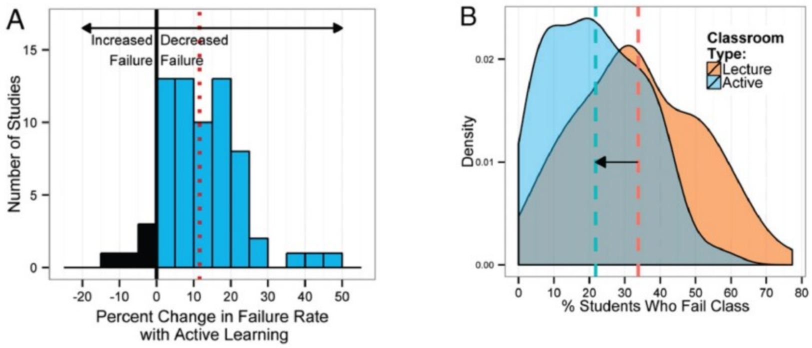
- Perhaps the strongest conclusion that can be made is the least surprising. Simply put, the greater the student's involvement or engagement in academic work or in the academic experience of college, the greater his or her level of knowledge acquisition and general cognitive development …(Pascarella 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

8

Engaged Pedagogies = Reduced Failure Rates

Evidence-based research on learning indicates that when students are actively involved in their education they are more successful and less likely to fail. A new PNAS report by Freeman et al., shows a significant decrease of failure rate in active learning classroom compared to traditional lecture



Freeman, Scott; Eddy, Sarah L.; McDonough, Miles; Smith, Michelle K.; Okoroafor, Nnadozie; Jordt, Hannah; Wenderoth, Mary Pat; Active learning increases student performance in science, engineering, and mathematics, 2014, Proc. Natl. Acad. Sci.

9

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

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

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

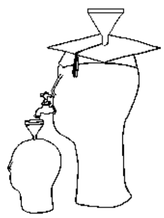
First Teaching Experience

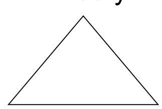
- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics

Lila M. Smith

Engineering Education

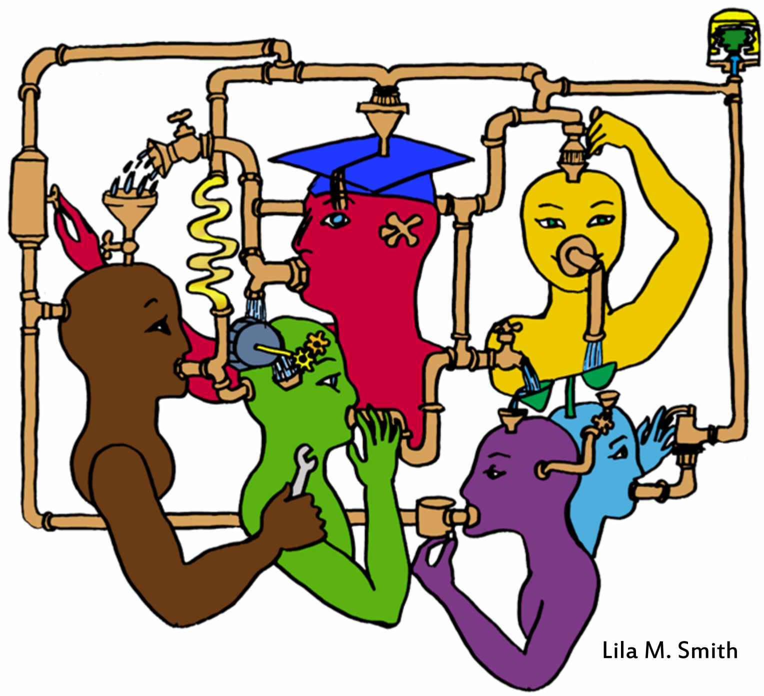
- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics
- Research – ?
- Theory – ?





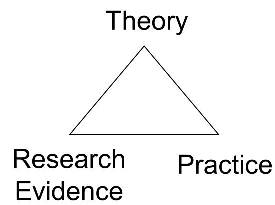
University of Minnesota College of Education
Social, Psychological and Philosophical
Foundations of Education

- 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



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.

Structuring Learning Goals To Meet the Goals of Engineering Education

Karl A. Smith, David W. Johnson, and Roger T. Johnson
University of Minnesota

The growing concern about engineering education in the United States has been the subject of many recent editorials and articles.* They point to the deteriorating quality of engineering and science education, the lack of adequate preparation in mathematics and science on the part of high school graduates, the shortage of engineers, and, especially, the shortage of college teachers of engineering. Unless corrective measures are taken, it may be more difficult in the coming years to achieve the ...

... the development of implementation skills for converting knowledge into action.

Interpersonal competence requires the development of the cognitive, affective and behavioral prerequisites for working with others to perform a task.[1] Among the skills required are communication, constructive conflict management, interpersonal problem solving, joint decision making and perspective-taking skills. Interpersonal competence is becoming increasingly important for engineers ...

... the interaction between society and technology.

Needs of Engineering Graduates

Many studies have been conducted on engineering education since it began at West Point in 1792, and these have been well summarized.[2] The earliest study (by Mann in 1918) called for a return to the basics; each of the subsequent ones emphasized diversity and a broad education,[3] and their general findings have been summarized by Cheit[4] in the following three statements:

1) There is renewed concern that, despite many efforts, engineering education is not yet incorporating what is called the "humanistic-social," "liberal," or "general" parts of the students' education.

2) Engineering education must be more broadly applied, that is, engineers must build bridges between science and the needs of society.

3) Engineers must be made decision makers, since, despite the growing importance of engineering to American life, engineers have not taken a correspondingly important part in the decision-making process.

The recommendations of these studies are similar and recurrent, but the need for change in engineering ...

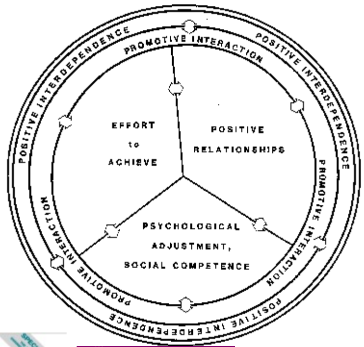
18

JEE December 1981

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.

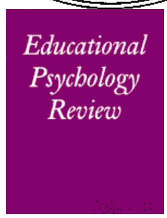
- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes



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

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. Journal on Excellence in College Teaching, *25*(3&4)

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.

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

ABSTRACT

Educators, researchers, and policy makers have advocated student involvement for some time as an essential aspect of meaningful learning. In the past twenty years engineering educators have implemented several means of better engaging their undergraduate students, including active and cooperative learning, learning communities, service learning, cooperative education, inquiry and problem-based learning, and team projects. This paper focuses on classroom-based pedagogies of engagement, particularly cooperative and problem-based learning. It includes a brief history, theoretical roots, research support, summary of practices, and suggestions for redesigning engineering classes and programs to include more student engagement. The paper also lays out the research ahead for advancing pedagogies aimed at more fully enhancing students' involvement in their learning.

Keywords: cooperative learning, problem-based learning, student engagement

I. INTRODUCTION TO THE PEDAGOGIES OF ENGAGEMENT

Russ Edgerton introduced the term "pedagogies of engagement" in his 2001 *Education White Paper* [1], in which he reflected on the projects on higher education funded by the Pew Charitable Trusts. He wrote:

"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."

Prior to Edgerton's paper, the widely distributed and influential publication called *The Seven Principles for Good Practice in Undergraduate Education* [2] stressed pedagogies of engagement in concept. Three of the principles speak directly to pedagogies of engagement, namely, that good practice encourages student-faculty contact, cooperation among students, and active learning.

More recently, the project titled The National Survey of Student Engagement (NSSE) [3] deepens our understanding of how students perceive classroom-based learning, in all its forms, as an element in the bigger issue of student engagement in their college education. The NSSE project conceives that student engagement is not just a single course in a student's academic career, but rather a pattern of his or her involvement in a variety of activities. As such, NSSE findings are a valuable assessment tool for colleges and universities to track how successful their academic practices are in engaging their student bodies. The NSSE project is grounded in the proposition that student engagement, the frequency with which students participate in activities that represent effective educational practice, is a meaningful proxy for collegiate quality and, therefore, by extension, quality of education. The annual survey of freshmen and seniors asks students how often they have, for example, participated in projects that required integrating ideas or information from various sources, used e-mail to communicate with an instructor, asked questions in class or contributed to class discussions, received prompt feedback from faculty on their academic performance, participated in community-based projects, or tutored or taught other students. Student responses are organized around five benchmarks:

1. *Level of academic challenge:* Schools encourage achievement by setting high expectations and emphasizing importance of student effort.
2. *Active and collaborative learning:* Students learn more when intensely involved in educational process and are encouraged to apply their knowledge in many situations.
3. *Student-faculty interaction:* Students able to learn from experts and faculty serve as role models and mentors.
4. *Enriching educational experience:* Learning opportunities inside and outside classroom (diversity, technology, collaboration, internships, community service, capstones) enhance learning.
5. *Supportive campus environment:* Students are motivated and satisfied at schools that actively promote learning and stimulate social interaction.

Astin's [4] large-scale correlational study of what matters in college (involving 27,064 students at 309 baccalaureate-granting institutions) found that two environmental factors were by far the most predictive of positive change in college students' academic development, personal development, and satisfaction. These two factors—interaction among students and interaction between faculty and

"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)

21

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

Reflection and Dialogue

- Individually reflect on your mental image of an effective teacher. Write for about 1 minute.
  - Jot down words or phrases
  - Construct a figure or diagram
- Discuss with your neighbor for about 2 minutes
  - Describe your mental image and talk about similarities and differences
  - Select one Element, Image, Comment, Story, etc. that you would like to present to the whole group if you are randomly selected
- Whole group discussion

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.

23

Good teaching comes from the identity and integrity of the teacher.

Good teachers possess a capacity for connectedness.

Parker J. Palmer in *The courage to teach: Exploring the inner landscape of a teacher's* life. Jossey-Bass, 1998.

College Teaching: What do we know about it?

- Five assertions about what we know about college teaching
  - Good teaching makes a difference
  - Teachers vary markedly
  - Some characteristics/methods are present in all good teaching
  - Teaching can be evaluated and rewarded
  - There is ample room for improvement.
- K. Patricia Cross, 1991 ASEE ERM Distinguished Lecture

25

- Four factors in good teaching, based on student ratings*:
  - Skill. Communicates in an exciting way.
  - Rapport. Understands and emphasizes with students.
  - Structure. Provides guidance to course and material.
  - Load. Requires moderate work load.
- *Student ratings of teaching are consistent (with other measures), unbiased, and useful. Students agree on good teaching and their views are consistent with faculty.

26

Pedagogies of Engagement

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

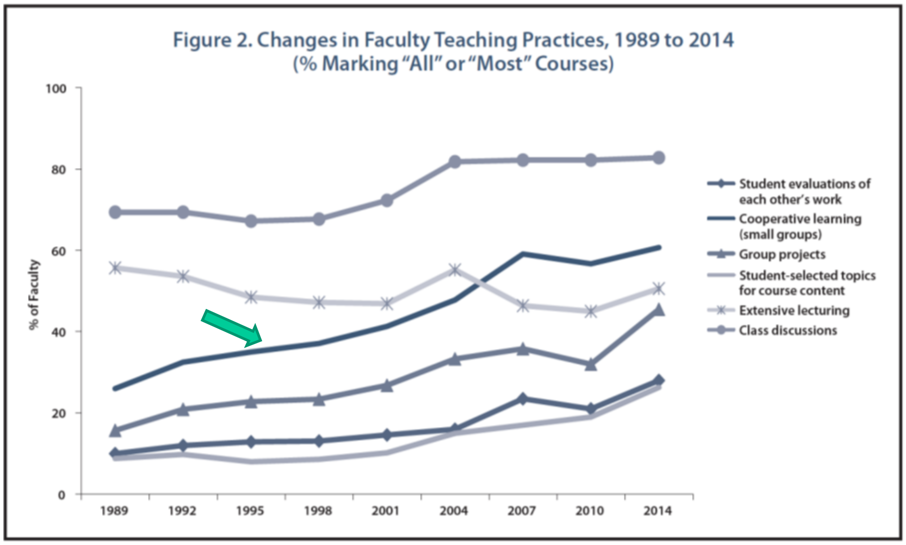
Individual Accountability

Face-to-Face Interaction

Karl A. Smith

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

Undergraduate Teaching Faculty: The 2013–2014 HERI Faculty Survey



http://heri.ucla.edu/monographs/HERI-FAC2014-monograph.pdf

29

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

30

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

Undergraduate Teaching Faculty, 2011*

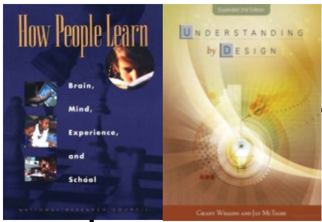
Methods Used in "All" or "Most"	STEM women	STEM men	All other women	All other men
Cooperative learning	60%	41%	72%	53%
Group projects	36%	27%	38%	29%
Grading on a curve	17%	31%	10%	16%
Student inquiry	43%	33%	54%	47%
Extensive lecturing	50%	70%	29%	44%

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

*"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



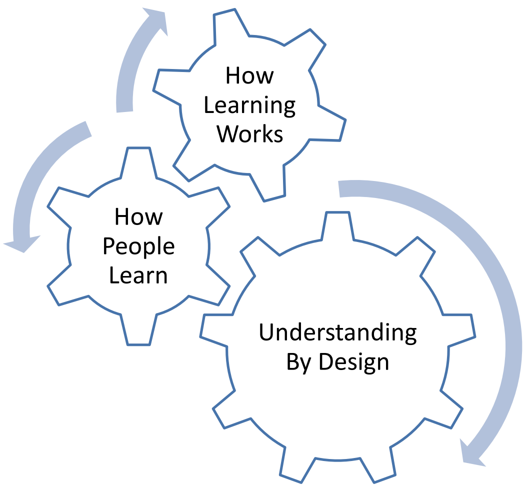
Science of Instruction (UbD)

Science of Learning (HPL)

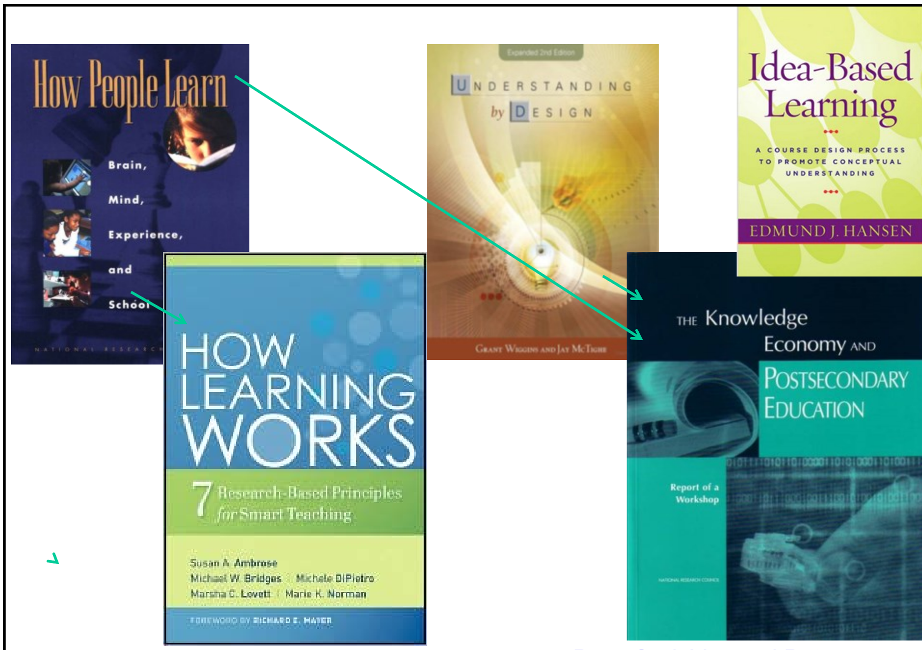
	No	Yes
Yes	Good Theory/ Poor Practice	Good Theory & Good Practice
No		Good Practice/ Poor Theory

Bransford, Brown & Cocking. 1999. *How People Learn.* National Academy Press.
Wiggins & McTighe, 2005. *Understanding by Design, 2ed*. ASCD.

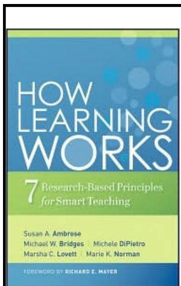
The Big Picture (Good Learning Theory and Good Instructional Practice)



34



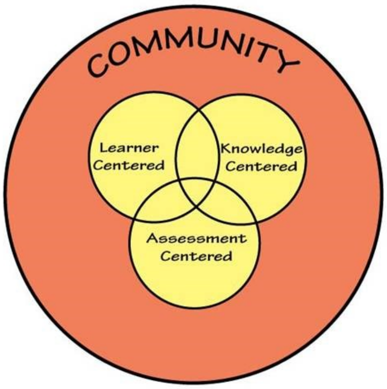
• Bransford, Vye and Bateman – Creating High Quality Learning Environments



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

How People Learn (HPL)

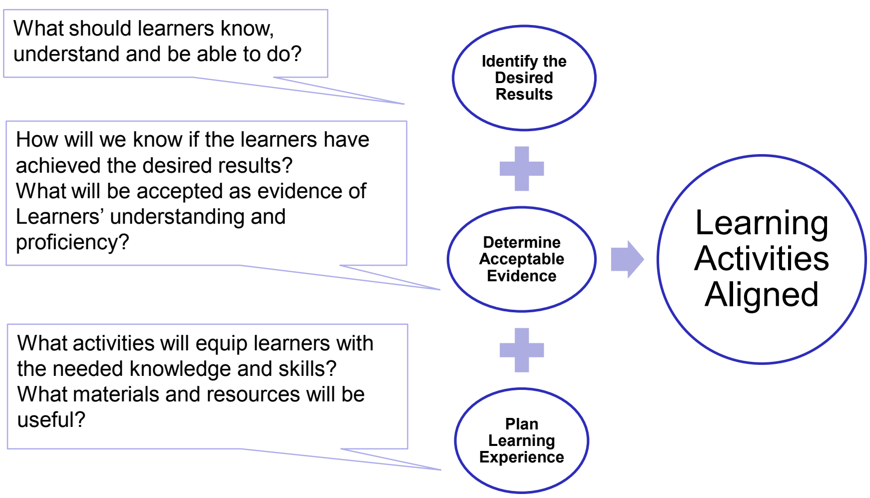
HPL Framework



- 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 Process



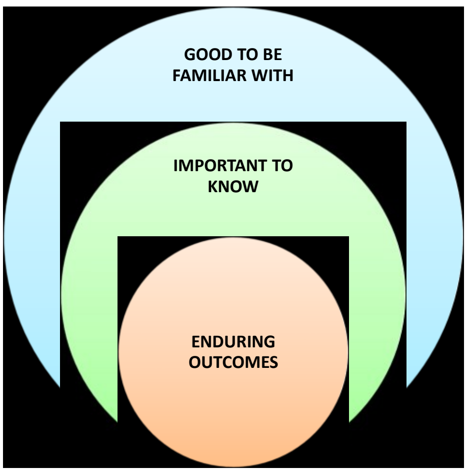
Understanding by Design Process vs. Engineering Design Process

Understanding by Design
- Identify the desired results
- Determine acceptable evidence
- Plan learning experiences

Engineering Design
- Determine requirements specifications
- Develop or use established metrics to measure against outcomes
- Plan and develop process, system, etc. to implement

Streveler, R.A, Smith, K.A., & Pilotte, M. 2012. Aligning course content, assessment, and delivery: Creating a context for outcomes-based education. In Khairiyah Mohd Yusof, Shahrin Mohammad, Naziha Ahmad Azli, Mohamed Noor Hassan, Azlina Kosnin & Sharifah Kamilah Syed Yusof (Eds.). *Outcome-based science, technology, engineering and mathematics: Innovative Practices*. (pp. 1 – 26). Hersey, PA: IGI Global.

Concept: Curricular Priorities



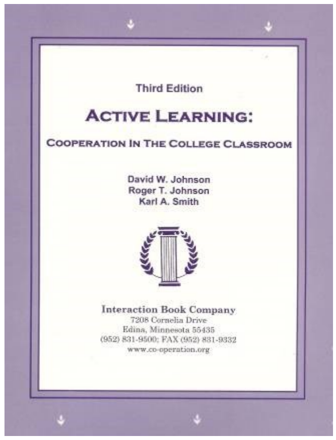
Things to Consider:

- 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 uncoverage?
- Are the topics big ideas **embedded in facts, skills and activities**?

-Understanding by Design, Wiggins and McTighe (1998)

Active Learning: Cooperation in the College Classroom

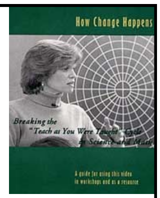
- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups

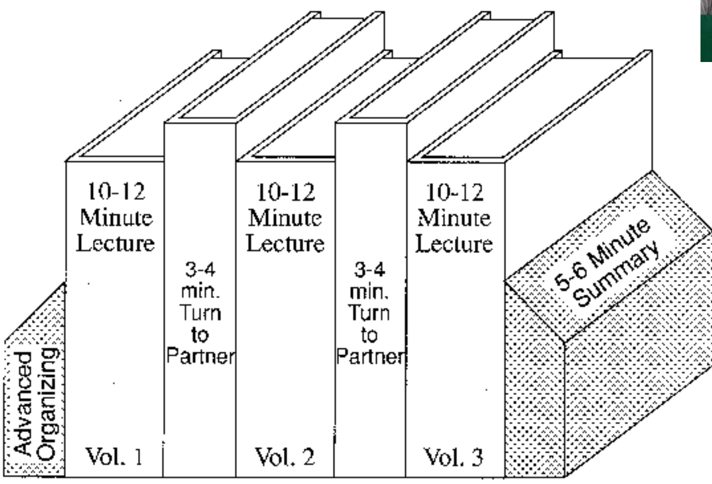


Notes: Cooperative Learning Handout (CL-College-814.doc)
[CL-College-814.doc]

41

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]

42

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

Physics

Eric Mazur - Harvard – http://galileo.harvard.edu
Peer Instruction – http://mazur.harvard.edu/research/detailspage.php?rowid=8
Richard Hake – http://www.physics.indiana.edu/~hake/

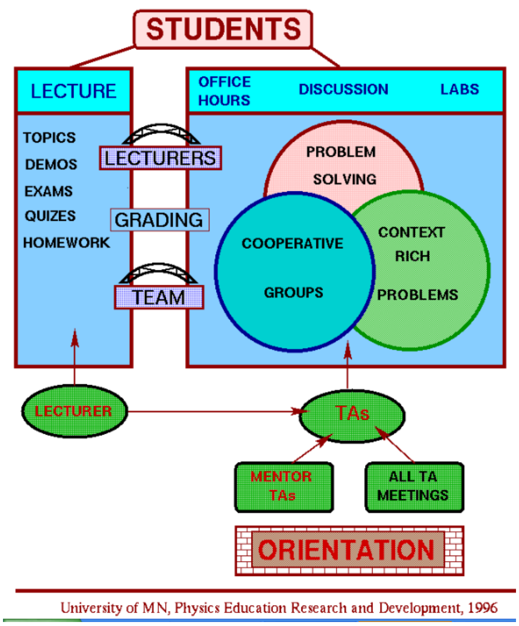
Chemistry
Chemistry ConcepTests - UW Madison - http://chemcollective.org/tests
Video: Making Lectures Interactive with ConcepTests
http://www.wcer.wisc.edu/archive/cl1/flag/cat/contests/contests7.htm
ModularChem Consortium – http://chemconnections.org/

STEMTEC - http://k12s.phast.umass.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 – http://bokcenter.harvard.edu/

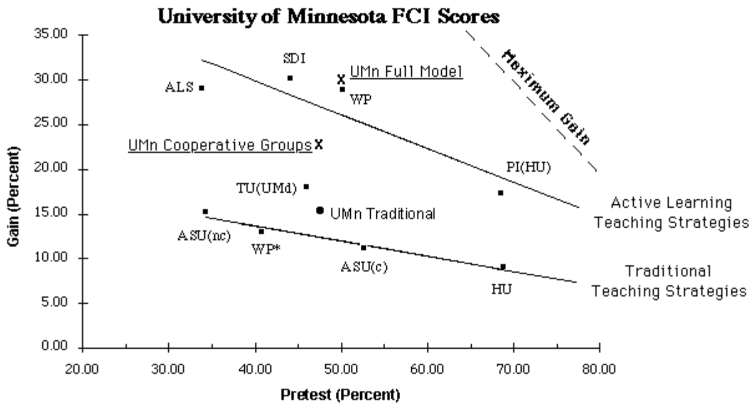
45

University of Minnesota Collaborative Model
for Large Introductory Courses



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

Conceptual Understanding



http://groups.physics.umn.edu/physed/Research/MNModel/FCI.html

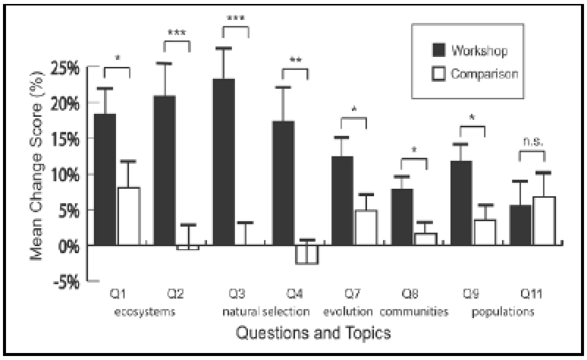
Physics (Mechanics) Concepts: The Force Concept Inventory (FCI)

- 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.

48

Workshop Biology

Traditional passive lecture vs. "Workshop biology"



Source: Udovic et al. 2002

Biology

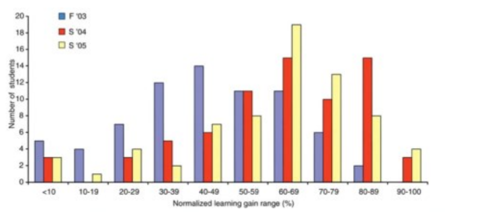


Figure 3. Comparison of normalized learning gains (% of possible maximum) in 10% increments on 12 common pretest and posttest questions for students in one traditional (F'03) and two interactive (S'04, S'05) classes. Normalized learning gains were computed as in Figure 2.

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

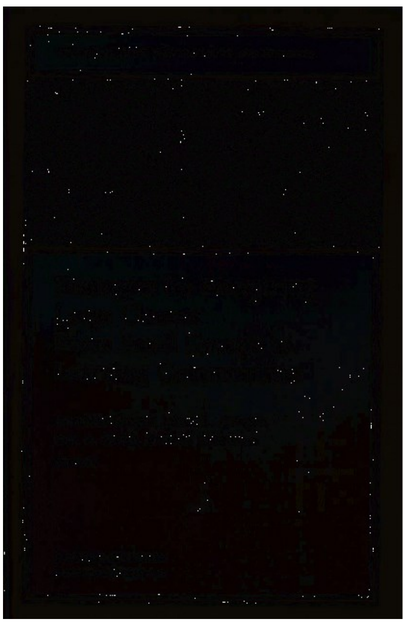
Assessment	of maximum score)		
	F'03	S'04	S'05
Pretest (12 questions)[a]	34	31	37
posttest (12 questions)[a]	65	74	72
Raw learning gain	31	43	38
Normalized learning gain[b]	46	62	61
Hourly exams	71	71	73
Final exam	77	71	76
Problem sets	82	85	90
Participation	N/A	86	86
Final total points	76	81	81

[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. ____________________

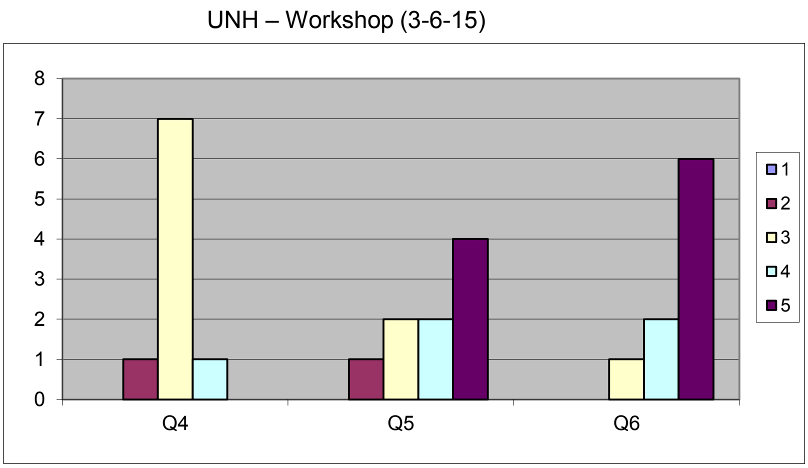
Celebrate Students' Hard Work

1. ____________________
2. ____________________

Session Summary (Minute Paper)

Reflect on the session

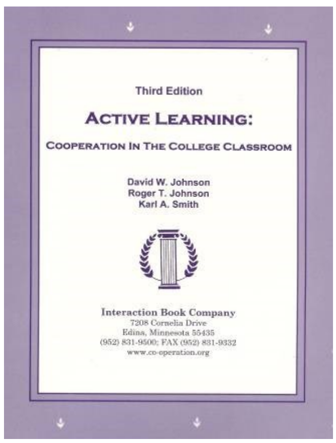
1. Most interesting, valuable, useful thing you learned.
2. Things that helped you learn.
3. Question, comments, suggestions.
4. Pace: Too slow 1 2 3 4 5 Too fast
5. Relevance: Little 1 2 3 4 5 Lots
6. Instructional Format: Ugh 1 2 3 4 5 Ah



Q4 – Pace: Too slow 1 . . . . 5 Too fast (3.0)
Q5 – Relevance: Little 1 . . . 5 Lots (4.0)
Q6 – Format: Ugh 1 . . . 5 Ah (4.6)

Active Learning: Cooperation in the College Classroom

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



Notes: Cooperative Learning Handout (CL-College-814.doc)
[CL-College-814.doc]

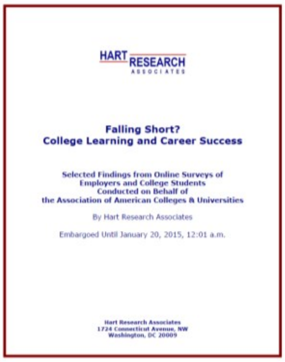
56

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.)


HART RESEARCH

Falling Short?
College Learning and Career Success

Selected Findings from Online Surveys of
Employers and College Students
Conducted on Behalf of
the Association of American Colleges & Universities

By Hart Research Associates

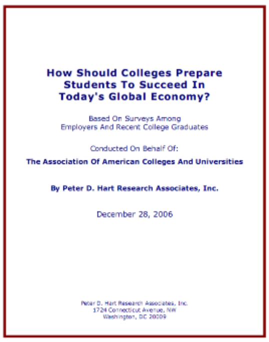
Embargoed Until January 20, 2015, 12:01 a.m.

Learning Outcomes Four in Five Employers Rate as Very Important
(Proportion of employers who rate each outcome an 8, 9, or 10 on a zero-to-10 scale)

	Employers %
The ability to effectively communicate orally	85
The ability to work effectively with others in teams	83
The ability to effectively communicate in writing	82
Ethical judgment and decision-making	81
Critical thinking and analytical reasoning skills	81
The ability to apply knowledge and skills to real-world settings	80

http://www.aacu.org/leap/public-opinion-research/2015-survey-results

59


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

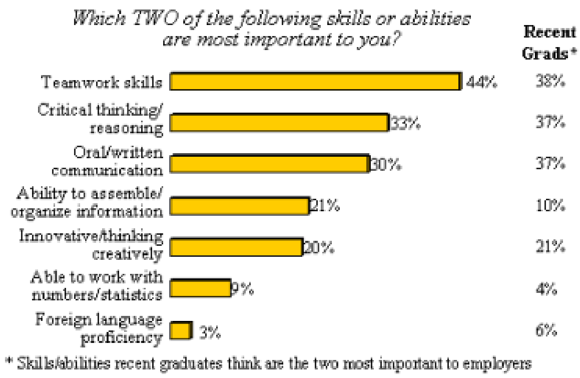
Based On Surveys Among
Employers And Recent College Graduates

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

By Peter D. Hart Research Associates, Inc.

December 28, 2006

Most Important Skills Employers Look For In New Hires



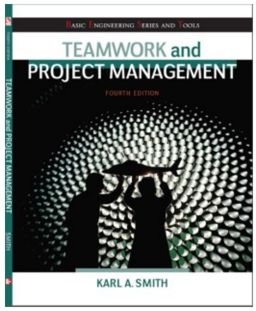
http://www.aacu.org/advocacy/leap/documents/Re8097abcombined.pdf

60

Top Three Main Engineering Work Activities

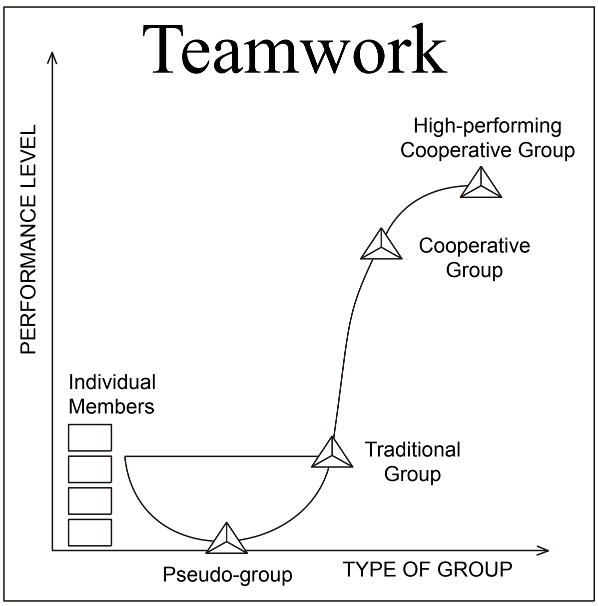
Engineering Total
- Design – 36%
- Computer applications – 31%
- Management – 29%

Civil/Architectural
- Management – 45%
- Design – 39%
- Computer applications – 20%



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

61



62

Reflection and Dialogue

- Individually reflect on the Characteristics of High Performing Teams. Think/Write for about 1 minute
  – Base on your experience on high performing teams,
  – Or your facilitation of high performing teams in your classes, or
  – Or your imagination
- Discuss with your team for about 3 minutes and record a list

Characteristics of High Performing Teams?

- ?
- ?

64

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).

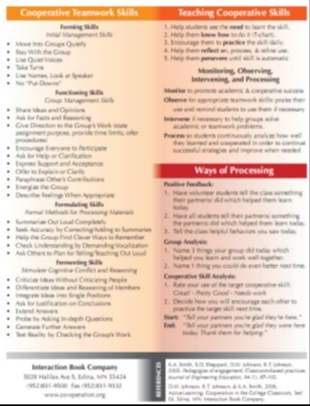
Key Concepts

- •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



Cooperative Teamwork Skills

Forming Skills
Initial Management Skills
- Move Into Groups Quietly
- Stay With the Group
- Use Quiet Voices
- Take Turns
- Use Names, Look at Speaker
- No "Put-Downs"

Functioning Skills
Group Management Skills
- Share Ideas and Opinions
- Ask for Facts and Reasoning
- Give Direction to the Group's Work (state assignment purpose, provide time limits, offer procedures)
- Encourage Everyone to Participate
- Ask for Help or Clarification
- Express Support and Acceptance
- Offer to Explain or Clarify
- Paraphrase Other's Contributions
- Energize the Group
- Describe Feelings When Appropriate

Formulating Skills
Formal Methods for Processing Materials
- Summarize Out Loud Completely
- Seek Accuracy by Correcting/Adding to Summaries
- Help the Group Find Clever Ways to Remember
- Check Understanding by Demanding Vocalization
- Ask Others to Plan for Telling/Teaching Out Loud

Fermenting Skills
Stimulate Cognitive Conflict and Reasoning
- Criticize Ideas Without Criticizing People
- Differentiate Ideas and Reasoning of Members
- Integrate Ideas into Single Positions
- Ask for Justification on Conclusions
- Extend Answers
- Probe by Asking In-depth Questions
- Generate Further Answers
- Test Reality by Checking the Group's Work

Teaching Cooperative Skills

1. Help students see the **need** to learn the skill.
2. Help them **know how** to do it (T-chart).
3. Encourage them to **practice** the skill daily.
4. Help them **reflect** on, process, & refine use.
5. Help them **persevere** until skill is automatic.

Monitoring, Observing, Intervening, and Processing

Monitor to promote academic & cooperative success
Observe for appropriate teamwork skills: praise their use and remind students to use them if necessary
Intervene if necessary to help groups solve academic or teamwork problems.
Process so students continuously analyze how well they learned and cooperated in order to continue successful strategies and improve when needed

Ways of Processing

Positive Feedback:
1. Have volunteer students tell the class something their partner(s) did which helped them learn today.
2. Have all students tell their partner(s) something the partner(s) did which helped them learn today.
3. Tell the class helpful behaviors you saw today.

Group Analysis:
1. Name 3 things your group did today which helped you learn and work well together.
2. Name 1 thing you could do even better next time.

Cooperative Skill Analysis:
1. Rate your use of the target cooperative skill: *Great! - Pretty Good - Needs work*
2. Decide how you will encourage each other to practice the target skill next time.

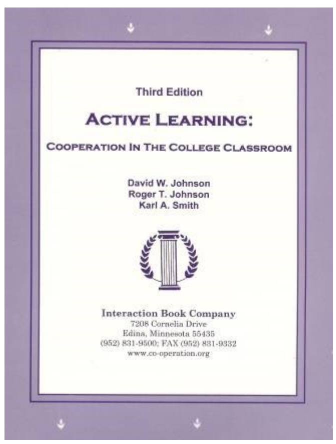
Start: *"Tell your partners you're glad they're here."*
End: *"Tell your partners you're glad they were here today. Thank them for helping."*

Interaction Book Company
5028 Halifax Ave S, Edina, MN 55424
(952)831-9500 Fax (952)831-9132
www.co-operation.org

REFERENCES
K.A. Smith, S.D. Sheppard, D.W. Johnson, R.T. Johnson, 2005. Pedagogies of engagement: Classroom-based practices. Journal of Engineering Education, 94 (1), 87-102.
D.W. Johnson, R.T. Johnson, & K.A. Smith, 2006. Active Learning: Cooperation in the College Classroom, 3rd Ed. Edina, MN: Interaction Book Company.

Active Learning: Cooperation in the College Classroom

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



Notes: Cooperative Learning Handout (CL-College-814.doc)
[CL-College-814.doc]

68

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

69

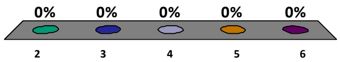
Decisions,Decisions

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

70

Optimal Group Size?

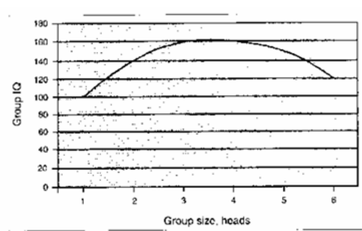
A. 2
B. 3
C. 4
D. 5
E. 6



71

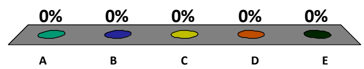
Formal Cooperative Learning Task Groups

Perkins, David. 2003. *King Arthur's Round Table: How collaborative conversations create smart organizations.* NY: Wiley.



Group Selection?

A. Self selection
B. Random selection
C. Stratified random
D. Instructor assign
E. Interest



73

Formal Cooperative Learning – Types of Tasks

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

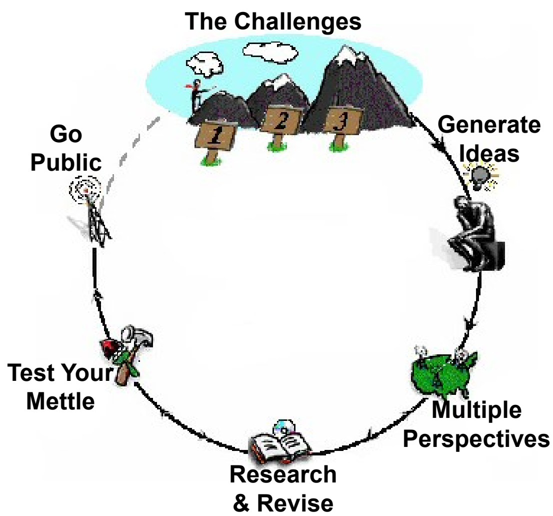
Challenge-Based Learning

- 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

75

Challenge-Based Learning



http://eecs.vanderbilt.edu/courses/ee213/challenge-based_Lab_design_concept.htm

76

Cooperative Problem-Based 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.

77

First Course Design Experience UMN – Institute of Technology

- Thinking Like an Engineer
- Problem Identification
- Problem Formulation
- Problem Representation
- Problem Solving

Problem-Based Learning

Team Member Roles

- Task Recorder
- Skeptic/Prober
- Process Recorder

79

Technical Estimation Problem

TASK:

INDIVIDUAL: Quick Estimate (10 seconds). Note strategy.

COOPERATIVE: Improved Estimate (~5 minutes). One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to arrive at the improved estimate.

EXPECTED CRITERIA FOR SUCCESS: Everyone must be able to explain the strategies used to arrive at your improved estimate.

EVALUATION: Best answer within available resources or constraints.

INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) your estimate and (b) how you arrived at it.

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

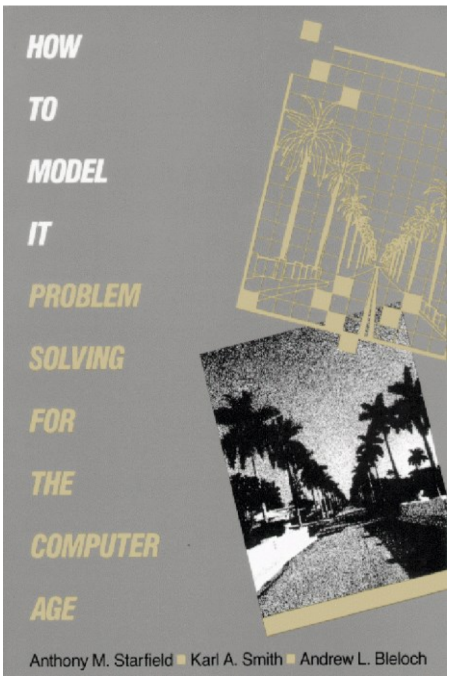
INTERGROUP COOPERATION: Whenever it is helpful, check procedures, answers, and strategies with another group.

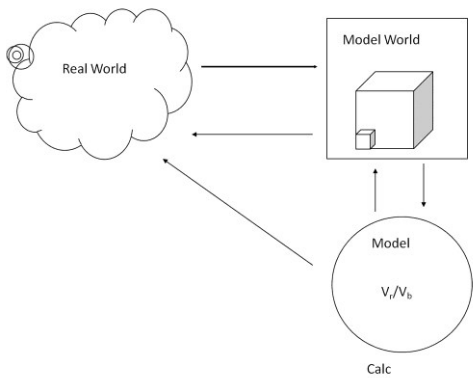
Group Reports

- Estimate
  - Group 1
  - Group 2
  - . . .

- Strategy used to arrive at estimate – assumptions, model, method, etc.

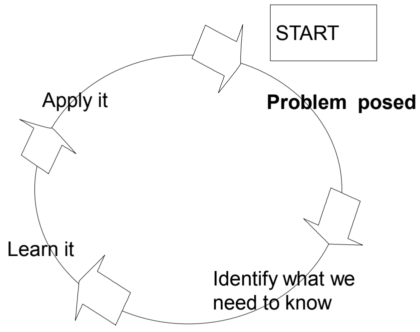
81



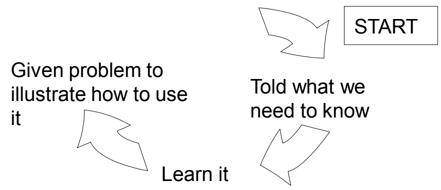


*Based on First Year Engineering course – Problem-based cooperative learning *How to Model It* published in 1990.

Problem-Based Learning



Subject-Based Learning



Normative Professional Curriculum:

1. Teach the relevant basic science,
2. Teach the relevant applied science, and
3. Allow for a practicum to connect the science to actual practice.

83

Group Processing
Plus/Delta Format

Plus (+) Things That Group Did Well	Delta (Δ) Things Group Could Improve

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 Problem-Based 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.

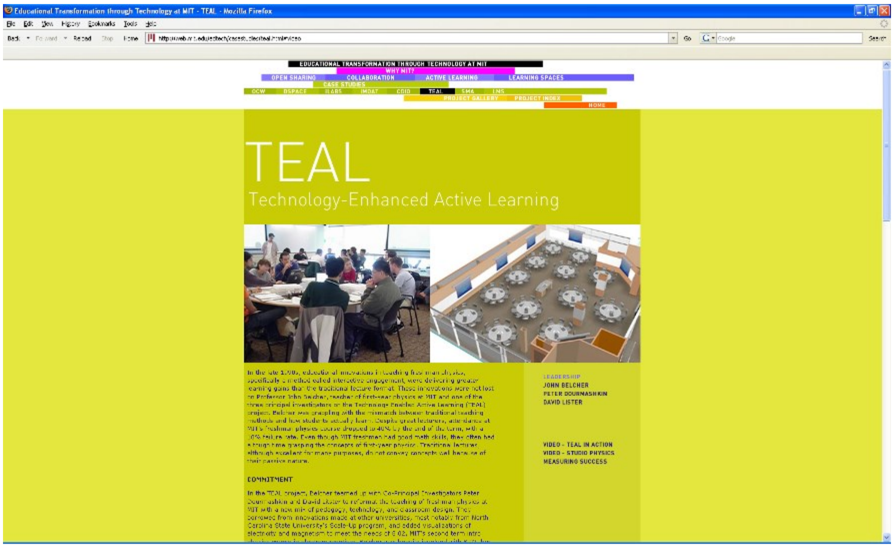
By SARA RIMER
Published: January 12, 2009

COMMENTS (00)
E-MAIL
PRINT
SINGLE PAGE

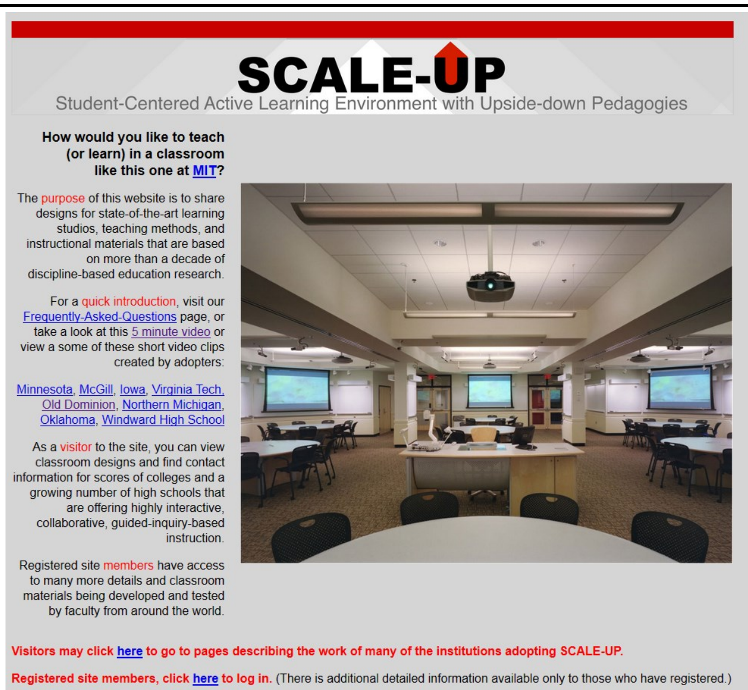
CAMBRIDGE, Mass. — For as long as anyone can remember, introductory physics at the Massachusetts Institute of Technology was taught in a vast windowless amphitheater known by its number,

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

87

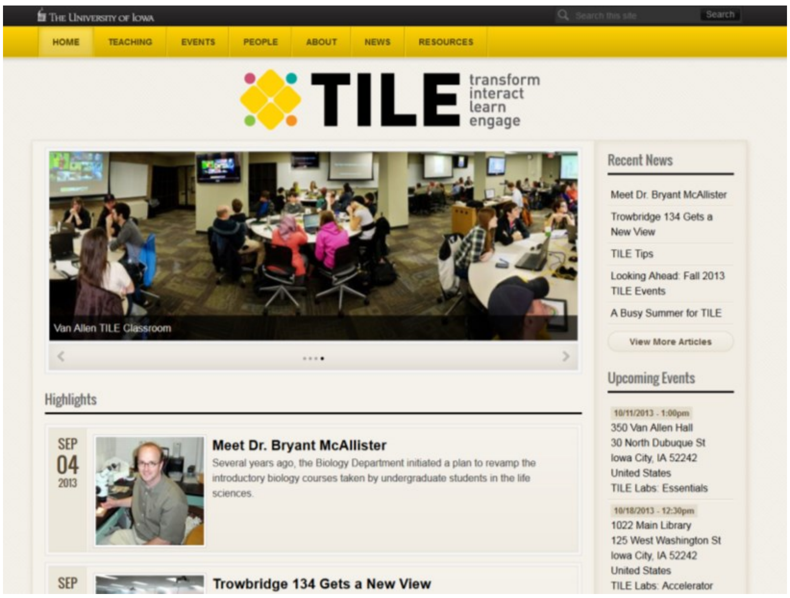


http://web.mit.edu/edtech/casestudies/teal.html#video



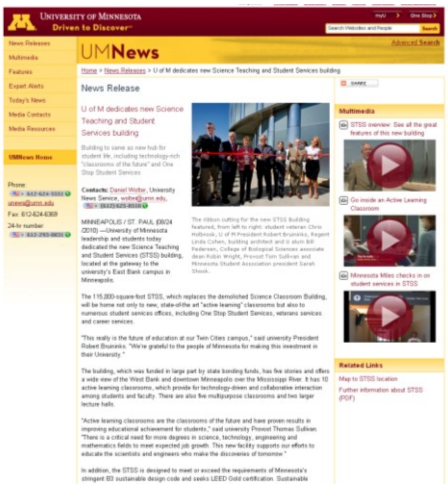
http://scaleup.ncsu.edu/

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



http://tile.uiowa.edu/

91



University of Minnesota
Driven to Discover

UMNews

Home > News Releases > U of M dedicates new Science Teaching and Student Services building

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

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

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=IfT_hoiuY8w

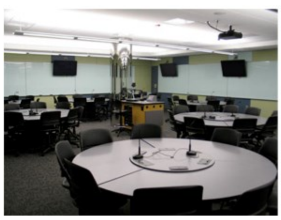
http://youtu.be/IfT_hoiuY8w

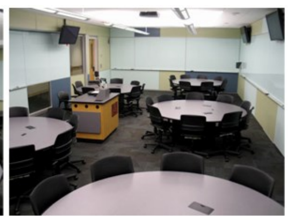
92

Inside an Active Learning Classroom

- STSS at the University of Minnesota

http://vimeo.com/andyub/activeclassroom

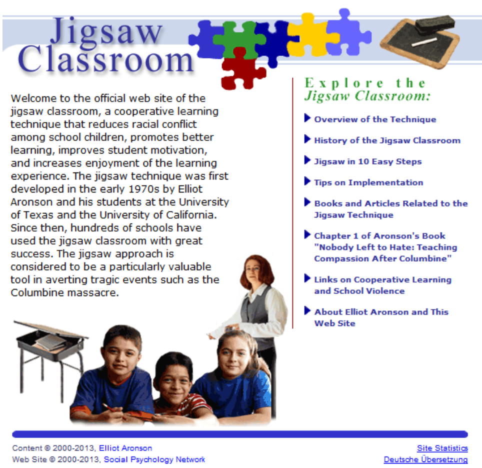




"I love this space! It makes me feel appreciated as a student, and I feel intellectually invigorated when I work and learn in it."

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

Cooperative Jigsaw



JIGSAW SCHEDULE

COOPERATIVE GROUPS (3-4 members)

PREPARATION PAIRS

CONSULTING/SHARING PAIRS

TEACHING/LEARNING IN COOPERATIVE GROUPS

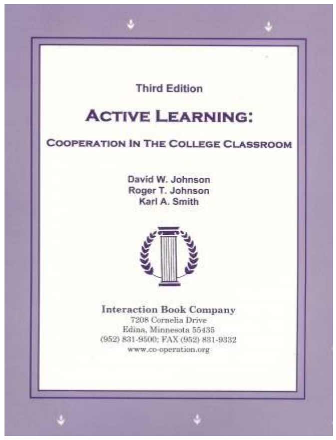
WHOLE CLASS REVIEW

www.jigsaw.org/

95

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)

96

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

97

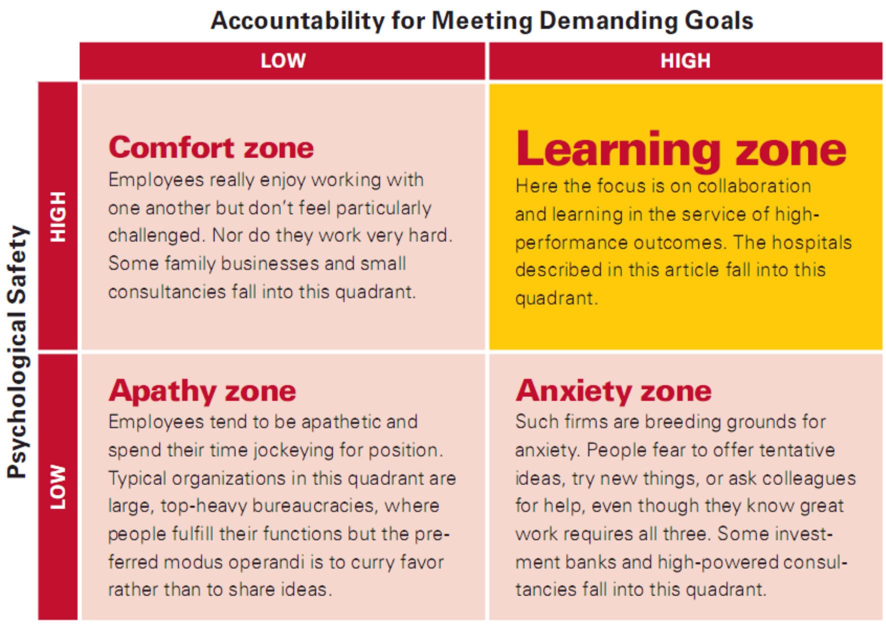
Creative Performance From Students (& Faculty) Requires Maintaining a Creative Tension Between

Challenge and Security

Pelz, Donald, and Andrews, Frank. 1966. Scientists in Organizations: Productive Climates for Research and Development. Ann Arbor: Institute for Social Research, University of Michigan.

Pelz, Donald. 1976. Environments for creative performance within universities. In Samuel Messick (Ed.), Individuality in learning, pp. 229-247. San Francisco: Jossey-Bass

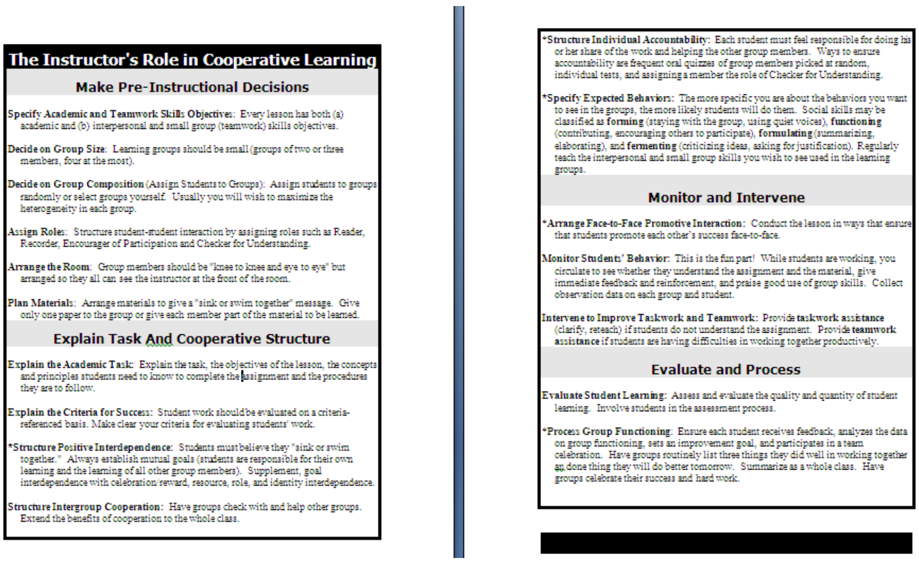
Edmonson, A.C. 2008. The competitive advantage of learning. Harvard Business Review 86 (7/8): 60-67.



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



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 Behaviors**: 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.

101

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: ____

102