Design and Implementation of Pedagogies of Engagement: Cooperative Learning and Challenge-Based Learning

Karl A. Smith
Engineering Education – Purdue University
STEM Education Center/Civil Eng – University of Minnesota
ksmith@umn.edu - http://www.ce.umn.edu/~smith/

Frontiers of Engineering Education – Educational Innovation Seminar Series (FOEE–EISS)

Worcester Polytechnic Institute

September 7, 2011

Session Layout

- Welcome & Overview
- Course Design Foundations
  - Understanding by Design (UdB)
    - Integrated Course Design (CAP Model)
      - Content – Assessment – Pedagogy
  - How People Learn (HPL)
    - How Learning Works (Ambrose, et al.)
- Pedagogies of Engagement – Cooperative Learning and Challenge Based Learning
  - Informal – Bookends on a Class Session
  - Formal Cooperative Learning
- Design and Implementation

2

Workshop Objectives

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

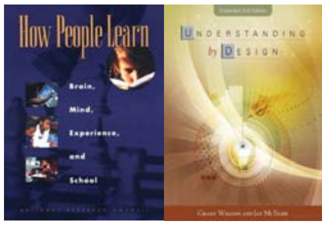
3

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

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

4

Design Foundations

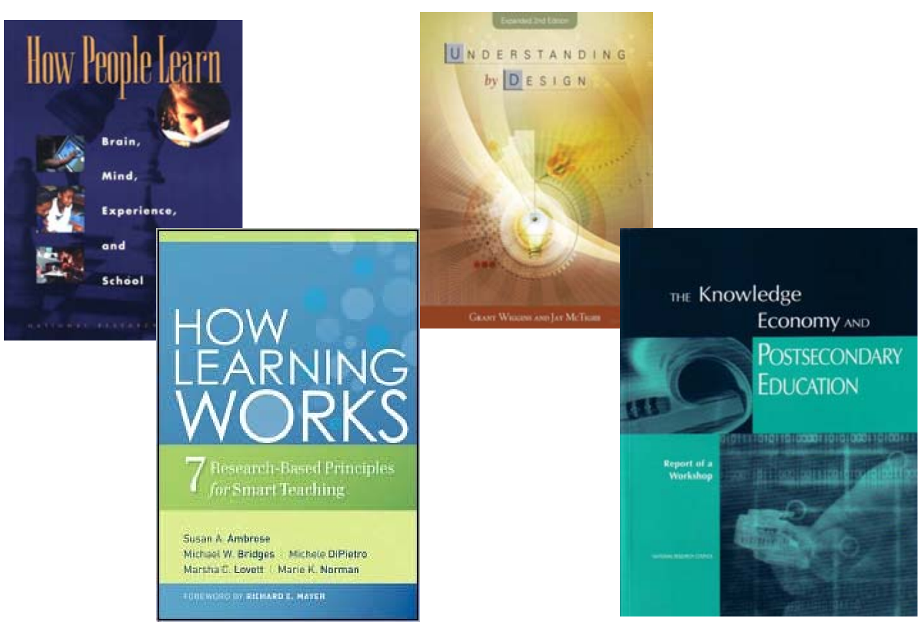


Science of Instruction (UbD)

Science of Learning (HPL)

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

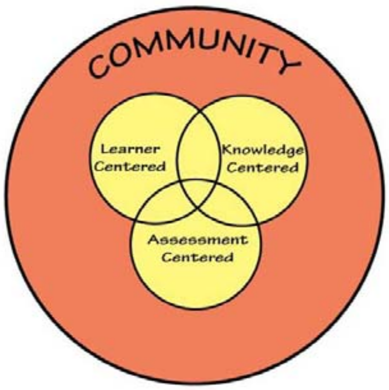
Sources: Bransford, Brown & Cocking. 1999. *How people learn.* National Academy Press.
Wiggins, G. & McTighe, J. 2005. *Understanding by design, 2ed.* ASCD.



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

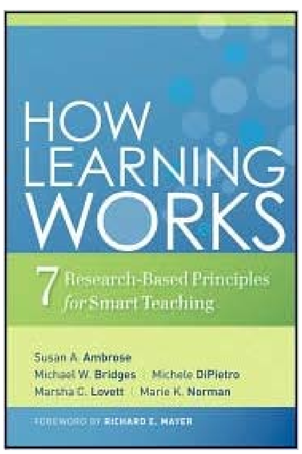
How People Learn (HPL)

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.



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

Understanding by Design

Wiggins & McTighe (1997, 2005)

Stage 1. Identify Desired Results

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

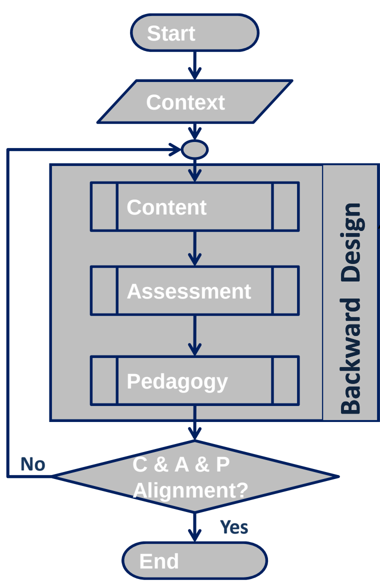
Stage 2. Determine Acceptable Evidence

Stage 3. Plan Learning Experiences and Instruction

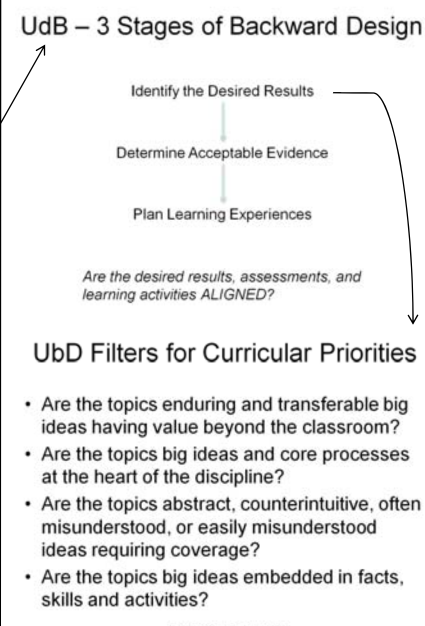
Overall: *Are the desired results, assessments, and learning activities ALIGNED?*

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

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



Streveler, Smith & Pilotte (2011)



Pedagogies of Engagement


Pedagogies of Engagement: Classroom-Based Practices

Karl A. Smith

Sheri D. Sheppard

David W. Johnson

Roger T. Johnson

Abstract

"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."

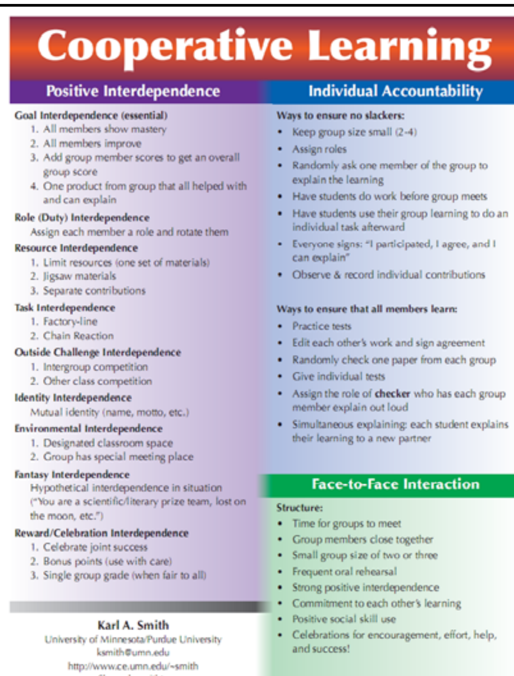
Russ Edgerton (reflecting on higher education projects funded by the Pew Memorial Trust)

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

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

Goal Interdependence (essential)
1. All members show mastery
2. All members improve
3. Add group member scores to get an overall group score
4. One product from group that all helped with and can explain

Role (Duty) Interdependence
Assign each member a role and rotate them

Resource Interdependence
1. Limit resources (one set of materials)
2. Jigsaw materials
3. Separate contributions

Task Interdependence
1. Factory-line
2. Chain Reaction

Outside Challenge Interdependence
1. Intergroup competition
2. Other class competition

Identity Interdependence
Mutual identity (name, motto, etc.)

Environmental Interdependence
1. Designated classroom space
2. Group has special meeting place

Fantasy Interdependence
Hypothetical interdependence in situation ("You are a scientific/literary prize team, lost on the moon, etc.")

Reward/Celebration Interdependence
1. Celebrate joint success
2. Bonus points (use with care)
3. Single group grade (when fair to all)

Individual Accountability

Ways to ensure no slackers:
- Keep group size small (2-4)
- Assign roles
- Randomly ask one member of the group to explain the learning
- Have students do work before group meets
- Have students use their group learning to do an individual task afterward
- Everyone signs: "I participated, I agree, and I can explain"
- Observe & record individual contributions

Ways to ensure that all members learn:
- Practice tests
- Edit each other's work and sign agreement
- Randomly check one paper from each group
- Give individual tests
- Assign the role of **checker** who has each group member explain out loud
- Simultaneous explaining: each student explains their learning to a new partner

Face-to-Face Interaction

Structure:
- Time for groups to meet
- Group members close together
- Small group size of two or three
- Frequent oral rehearsal
- Strong positive interdependence
- Commitment to each other's learning
- Positive social skill use
- Celebrations for encouragement, effort, help, and success!

Karl A. Smith
University of Minnesota/Purdue University
ksmith@umn.edu
http://www.ce.umn.edu/~smith
Skype: kasmithtc

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

Reflection and Dialogue

- Individually reflect on your familiarity with (1) Integrated Course Design and (2) Pedagogies of Engagement, especially Cooperative Learning. Write for about 1 minute
  - Key ideas, insights, applications – Success Stories
  - Questions, concerns, challenges
- Discuss with your neighbor for about 3 minutes
  - Select one Insight, Success Story, Comment, Question, etc. that you would like to present to the whole group if you are randomly selected

Understanding by Design

Stage 2. Determine Acceptable Evidence

Types of Assessment

Quiz and Test Items:
Simple, content-focused test items

Academic Prompts:
Open-ended questions or problems that require the student to think critically

Performance Tasks or Projects:
Complex challenges that mirror the issues or problems faced by graduates, they are authentic

16

Feedback and Assessment

- Forward Looking Assessment
  - Questions that incorporate course concepts in a real-life context
- Criteria and Standards
  - What traits or characteristics are indicative of high quality work?
- Self-Assessment
  - Allow students to gauge their own learning.
- FIDeLity Feedback
  - **F**requent, **I**mmediate, **D**iscriminating, **L**ovingly delivered

Taxonomies of Types of Learning

Bloom's taxonomy of educational objectives: Cognitive Domain (Bloom & Krathwohl, 1956)

A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives (Anderson & Krathwohl, 2001).

Facets of understanding (Wiggins & McTighe, 1998)

Taxonomy of significant learning (Fink, 2003)

Evaluating the quality of learning: The SOLO taxonomy (Biggs & Collis, 1982)

18

The Six Major Levels of Bloom's Taxonomy of the Cognitive Domain (with representative behaviors and sample objectives)

Knowledge. Remembering information *Define, identify, label, state, list, match*

- Identify the standard peripheral components of a computer
- Write the equation for the Ideal Gas Law

Comprehension. Explaining the meaning of information *Describe, generalize, paraphrase, summarize, estimate*

- In one sentence explain the main idea of a written passage
- Describe in prose what is shown in graph form

Application. Using abstractions in concrete situations *Determine, chart, implement, prepare, solve, use, develop*

- Using principles of operant conditioning, train a rate to press a bar
- Derive a kinetic model from experimental data

Analysis. Breaking down a whole into component parts *Points out, differentiate, distinguish, discriminate, compare*

- Identify supporting evidence to support the interpretation of a literary passage
- Analyze an oscillator circuit and determine the frequency of oscillation

Synthesis. Putting parts together to form a new and integrated whole *Create, design, plan, organize, generate, write*

- Write a logically organized essay in favor of euthanasia
- Develop an individualized nutrition program for a diabetic patient

Evaluation. Making judgments about the merits of ideas, materials, or phenomena *Appraise, critique, judge, weigh, evaluate, select*

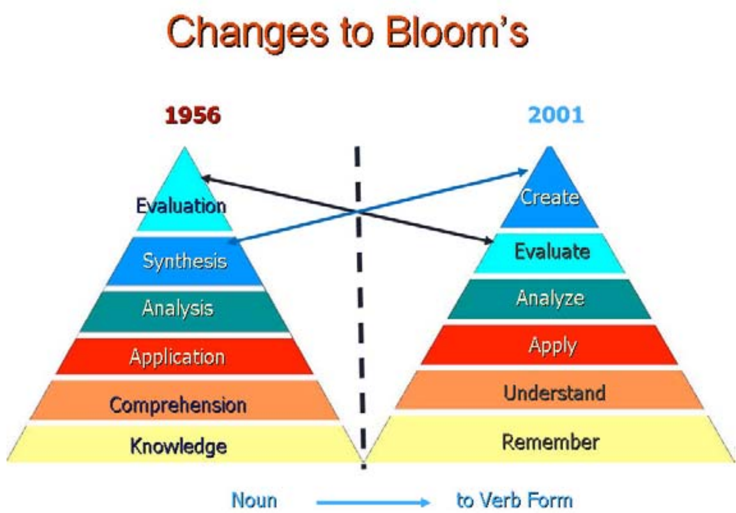
- Assess the appropriateness of an author's conclusions based on the evidence given
- Select the best proposal for a proposed water treatment plant

The Cognitive Process Dimension →

The Knowledge Dimension ↓

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements						
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures						
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures						
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge						

(Anderson & Krathwohl, 2001).



http://www.uwsp.edu/education/lwilson/curric/newtaxonomy.htm

21

Understanding by Design

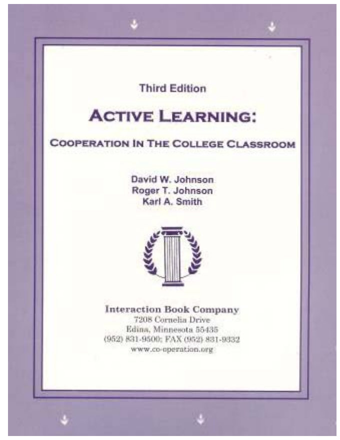
Stage 3. Plan Learning Experiences & Instruction

- What enabling knowledge (facts, concepts, and principles) and skills (procedures) will students need to perform effectively and achieve desired results?
- What activities will equip students with the needed knowledge and skills?
- What will need to be taught and coached, and how should it be taught, in light of performance goals?
- What materials and resources are best suited to accomplish these goals?
- Is the overall design coherent and effective?

22

Active Learning: Cooperation in the College Classroom

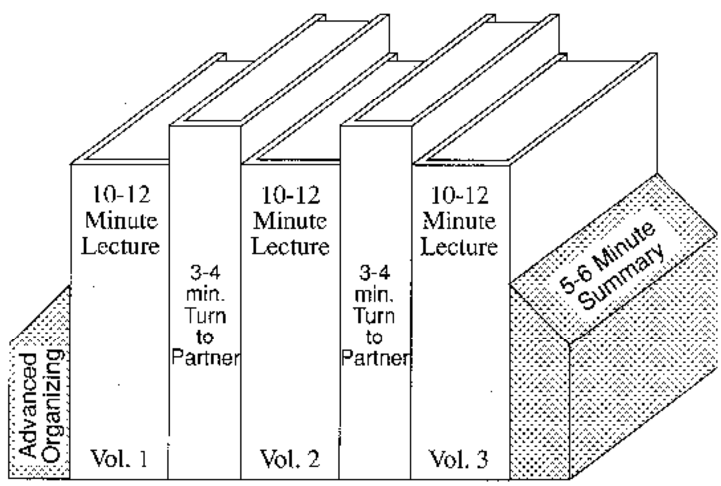
- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups



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

23

Book Ends on a Class Session



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?

Advance Organizer

"The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."

David Ausubel - Educational psychology: A cognitive approach, 1968.

26

Quick Thinks

- Reorder the steps
- Paraphrase the idea
- Correct the error
- Support a statement
- Select the response

Johnston, S. & Cooper,J. 1997. Quick thinks: Active-thinking in lecture classes and televised instruction. Cooperative learning and college teaching, 8(1), 2-7.

27

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

28

Minute Paper

- What was the most useful or meaningful thing you learned during this session?
- What question(s) remain uppermost in your mind as we end this session?
- What was the "muddiest" point in this session?
- Give an example or application
- Explain in your own words . . .

Angelo, T.A. & Cross, K.P. 1993. Classroom assessment techniques: A handbook for college teachers. San Francisco: Jossey Bass.

29

Session Summary (Minute Paper)

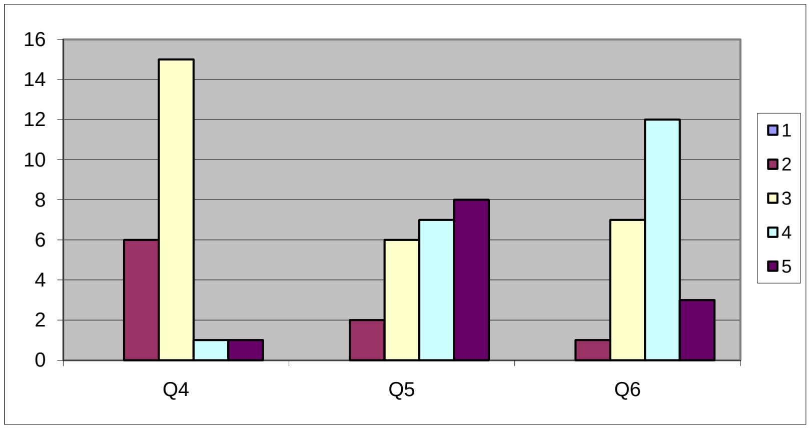
Reflect on the session:

1. Most interesting, valuable, useful thing you learned.
2. Things that helped you learn.
3. Question, comments, suggestions.

4. Pace: Too slow 1 . . . . 5 Too fast
5. Relevance: Little 1 . . . 5 Lots
6. Instructional Format: Ugh 1 . . . 5 Ah

30

MOT 8221 – Spring 2011 – Session 1 (3/25/11)

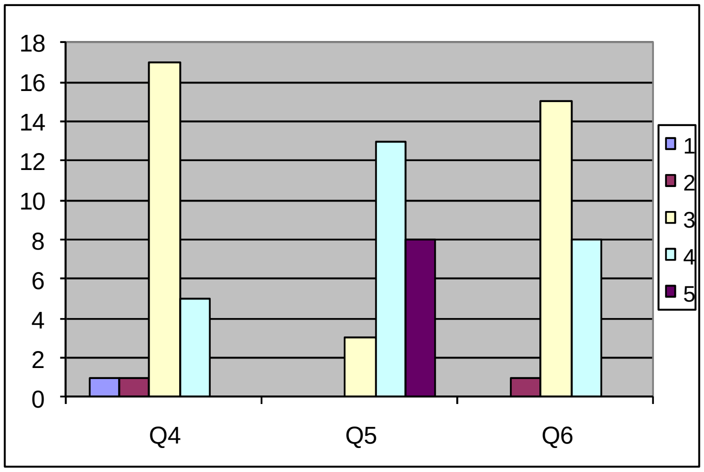


Q4 – Pace: Too slow 1 . . . . 5 Too fast (2.9)
Q5 – Relevance: Little 1 . . . 5 Lots (3.9)
Q6 – Format: Ugh 1 . . . 5 Ah (3.7)

Minute Paper – Reflection

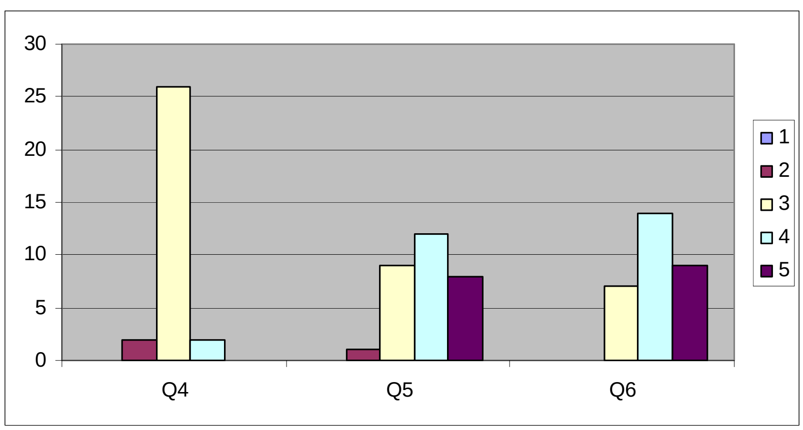
1. Most interesting, valuable, useful thing you learned.
2. Question/Topic/Issue you would like to have addressed
3. Current challenge, comments, suggestions, etc.
4. Pace: Too Slow 1 2 3 4 5 Too Fast
5. Relevance: Low 1 2 3 4 5 High
6. Discussion Control: Too Low 1 2 3 4 5 Too High

MOT 8221 – Spring 2011 – Session 2 (4/8/11)



Q4 – Pace: Too slow 1 . . . . 5 Too fast (3.1)
Q5 – Relevance: Little 1 . . . 5 Lots (4.2)
Q6 – Discussion Control: Too Low 1 . . . 5 Too High (3.3)

MOT 8221 – Spring 2010 – Session 1 (1/29/10)



Q4 – Pace: Too slow 1 . . . . 5 Too fast (3.0)
Q5 – Relevance: Little 1 . . . 5 Lots (3.9)
Q6 – Format: Ugh 1 . . . 5 Ah (4.1)

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

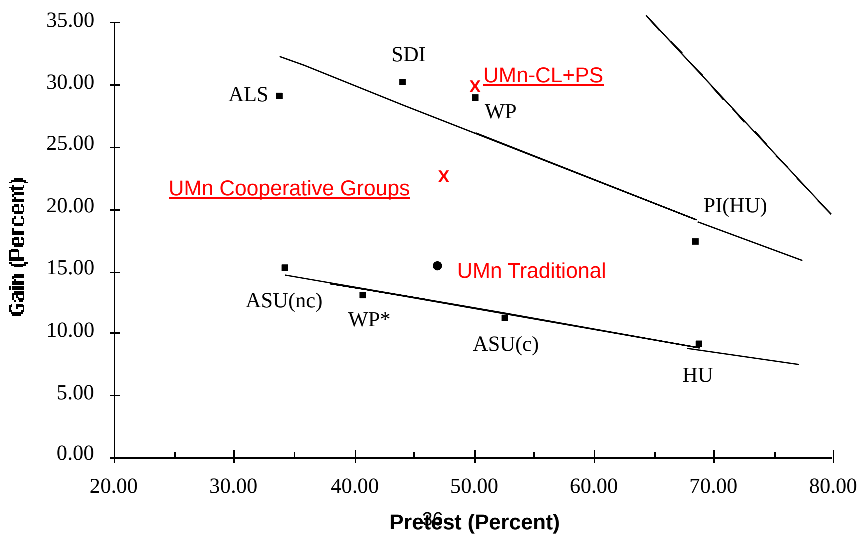
Physics
Peer Instruction
Eric Mazur - Harvard – http://galileo.harvard.edu
Peer Instruction – www.prenhall.com
Richard Hake – http://www.physics.indiana.edu/~hake/

Chemistry
Chemistry ConcepTests - UW Madison
www.chem.wisc.edu/~concept
Video: Making Lectures Interactive with ConcepTests
ModularChem Consortium – http://mc2.cchem.berkeley.edu/

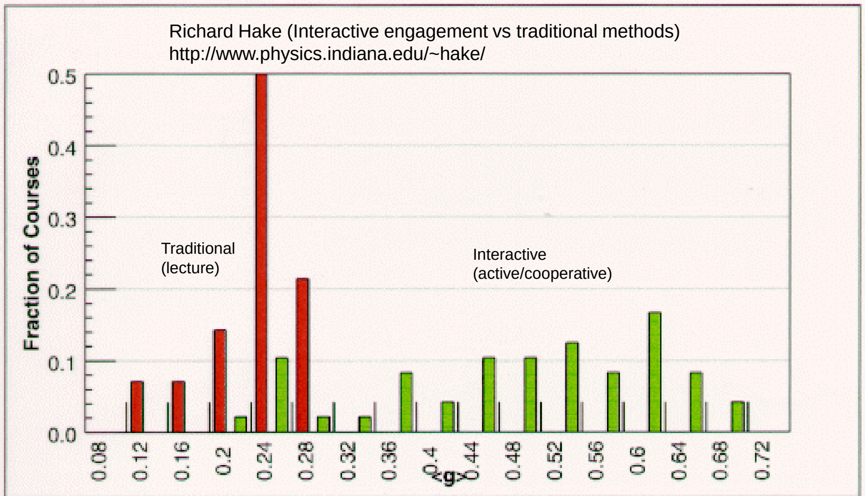
STEMTEC
Video: How Change Happens: Breaking the “Teach as You Were Taught” Cycle – Films for the Humanities & Sciences – www.films.com

Harvard – Derek Bok Center
Thinking Together & From Questions to Concepts: Interactive Teaching in Physics – www.fas.harvard.edu/~bok_cen/ 35

The “Hake” Plot of FCI



36



<g> = Concept Inventory Gain/Total

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

III. CONCEPTUAL TEST RESULTS

A. Gain vs Pretest Graph - All Data

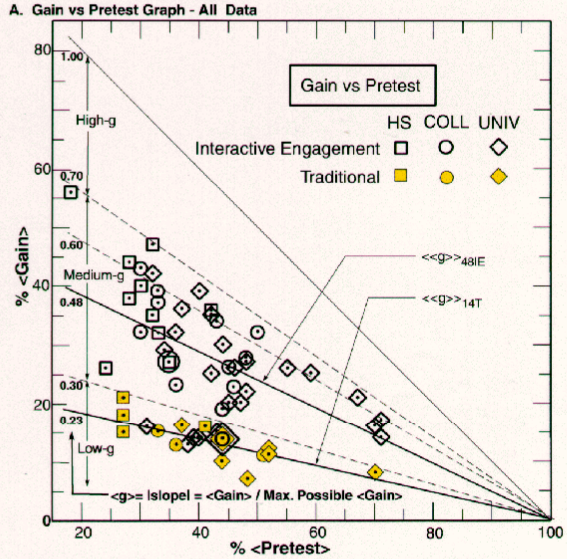


Fig. 1. %<Gain> vs %<Pretest> score on the conceptual Mechanics Diagnostic (MD) or Force Concept Inventory (FCI) tests for 62 courses enrolling a total N = 6542 students: 14 traditional (T) courses (N = 2084) which made little or no use of interactive engagement (IE) methods, and 48 IE courses (N = 4458)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

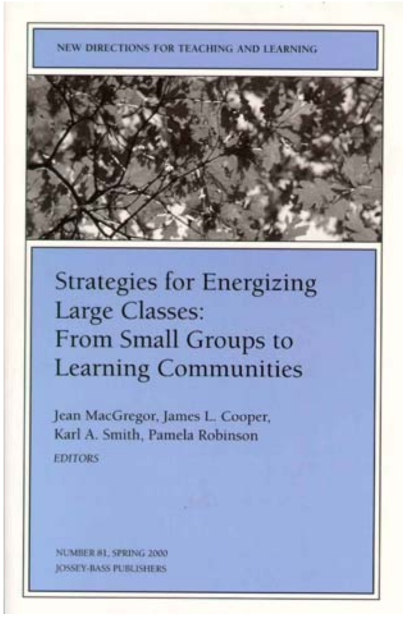
Physics (Mechanics) Concepts: The Force Concept Inventory (FCI)

- 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.

39

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



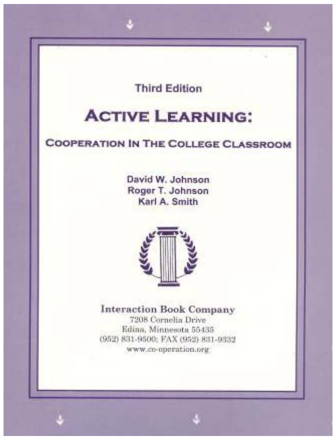
Strategies for Energizing Large Classes: From Small Groups to Learning Communities:

Jean MacGregor,
James Cooper,
Karl Smith,
Pamela Robinson

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

Active Learning: Cooperation in the College Classroom

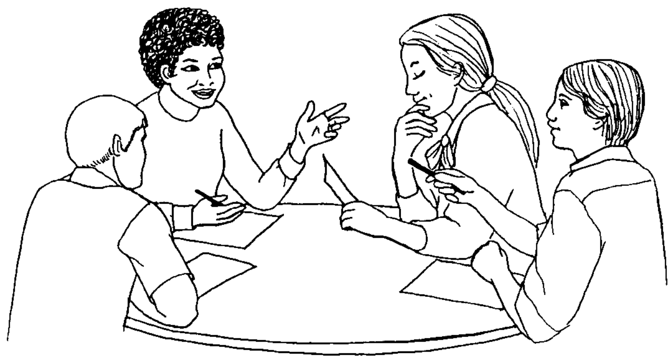
- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups

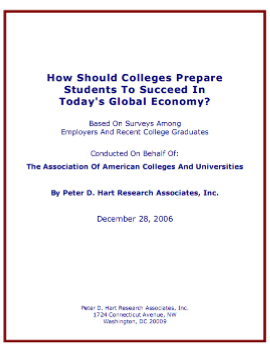


See Cooperative Learning Handout (CL College-804.doc)

42

Formal Cooperative Learning Task Groups





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

44

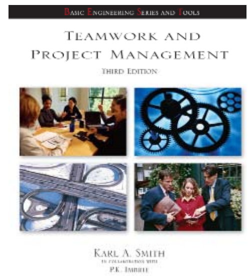
Top Three Main Engineering Work Activities

Engineering Total

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

Civil/Architectural

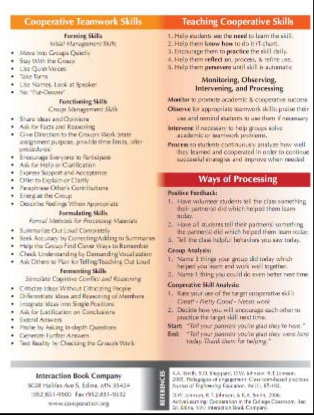
- Management – 45%
- Design – 39%
- Computer applications – 20%



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

Teamwork Skills

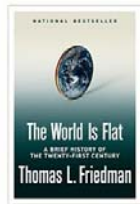
- Communication
  - Listening and Persuading
- Decision Making
- Conflict Management
- Leadership
- Trust and Loyalty



Ideo's five-point model for strategizing by design:
Hit the Streets
Recruit T-Shaped People
Build to Think
The Prototype Tells a Story
Design Is Never Done

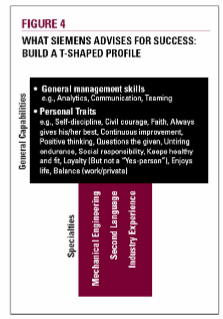
Design Thinking

Discipline Thinking



Tom Friedman
Horizontalize
Ourselves

CQ+PQ>IQ



AAC&U *College Learning For the New Global Century*

47

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

48

Formal Cooperative Learning – Types of Tasks

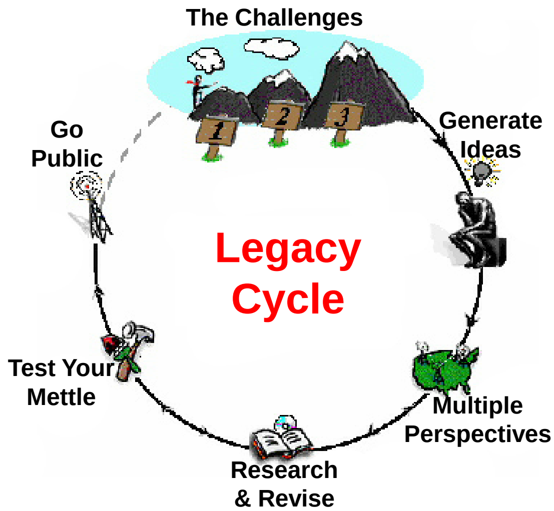
1. Jigsaw – Learning new conceptual/procedural material
2. Peer Composition or Editing
3. Reading Comprehension/Interpretation
4. **Problem Solving, Project, or Presentation**
5. Review/Correct Homework
6. Constructive Academic Controversy
7. Group Tests

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

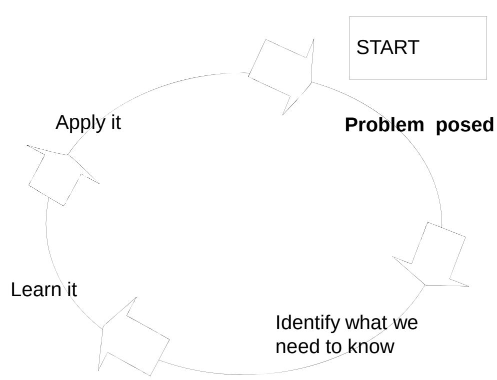
Challenge-Based Instruction with the Legacy Cycle



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

51

Problem-Based Learning



52

Problem-Based Cooperative Learning

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

Jodi Hilton for The New York Times

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

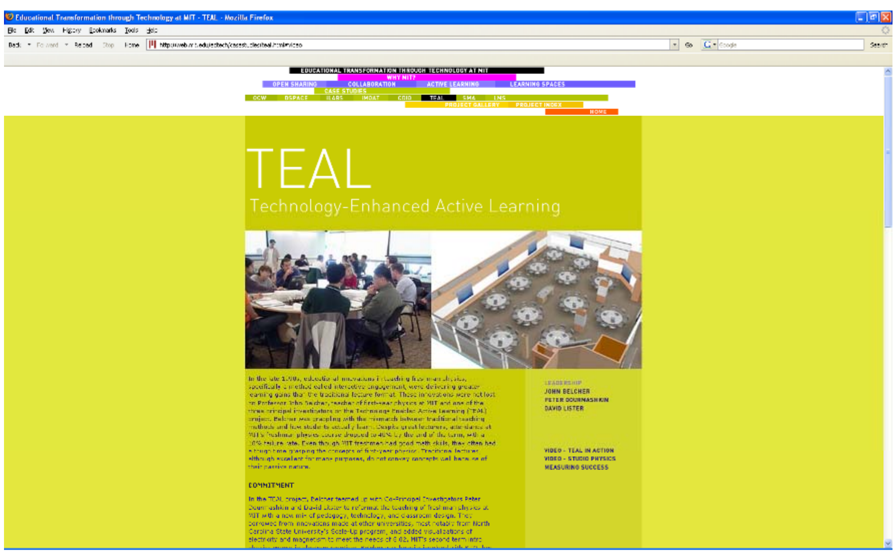
By SARA RIMER
Published: January 12, 2009

COMMENTS (00)
E-MAIL
PRINT
SINGLE PAGE

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

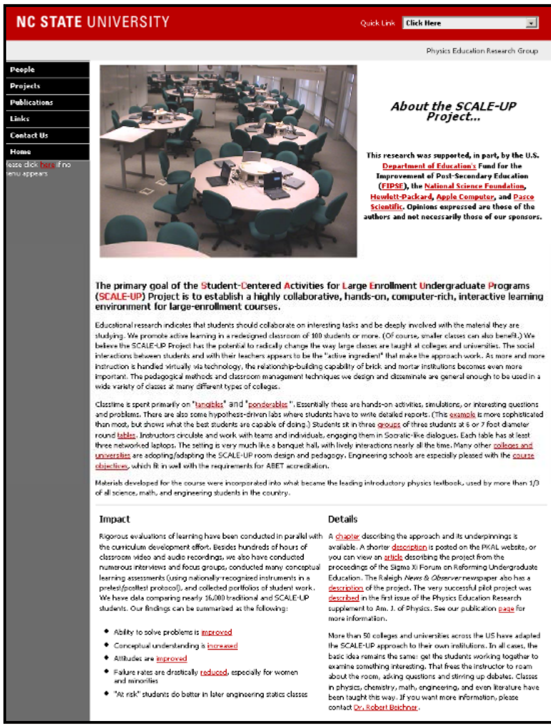
January 13, 2009—New York Times – http://www.nytimes.com/2009/01/13/us/13physics.html?em

53



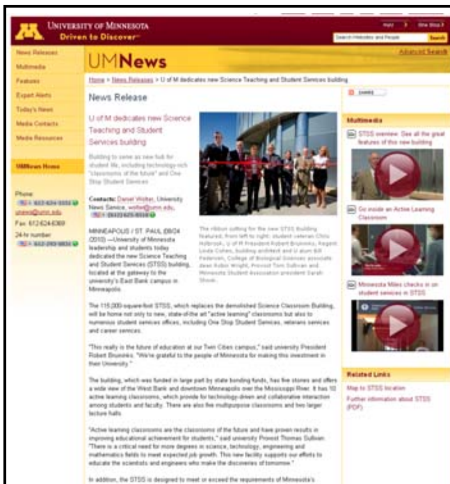
http://web.mit.edu/edtech/casestudies/teal.html#video

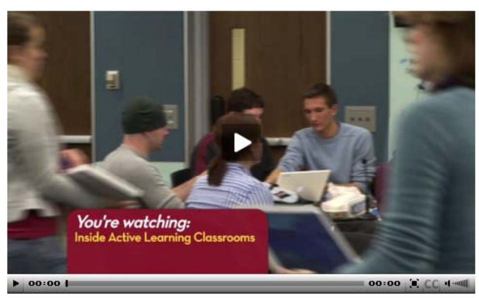
54



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

55





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

56

PROBLEM-BASED LEARNING

- UD PBL articles and books
- UD PBL in the news
- Sample PBL problems
- UD PBL courses and syllabi
- PBL Clearinghouse
- PBL Conferences and Other PBL sites
- Institute for Transforming Undergraduate Education
- Other related UD sites

"How can I get my students to think?" is a question asked by many faculty, regardless of their disciplines. Problem-based learning (PBL) is an instructional method that challenges students to "learn to learn," working cooperatively in groups to seek solutions to real world problems. These problems are used to engage students' curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources. -- *Barbara Duch*

PBL2002:
A Pathway to Better Learning

Recipient of 1999 Hesburgh Certificate of Excellence

Please direct comments, suggestions, or requests to ud-pbl@udel.edu.
"http://www.udel.edu/pbl/"
Last updated March 13, 2004.

http://www.udel.edu/pbl/

Problem-Based Cooperative Learning

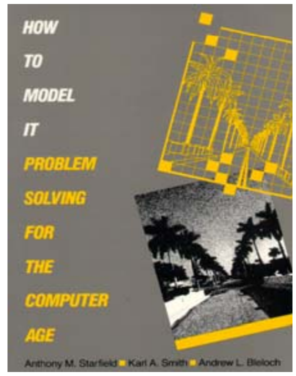
Karl A. Smith
Engineering Education – Purdue University
Civil Engineering - University of Minnesota
ksmith@umn.edu
http://www.ce.umn.edu/~smith

Estimation Exercise

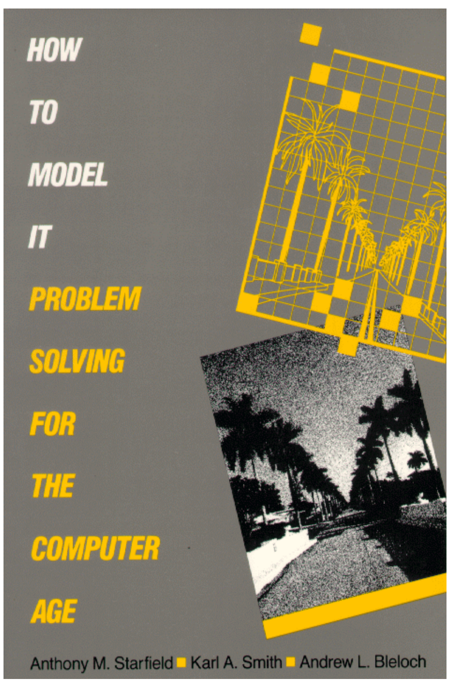
58

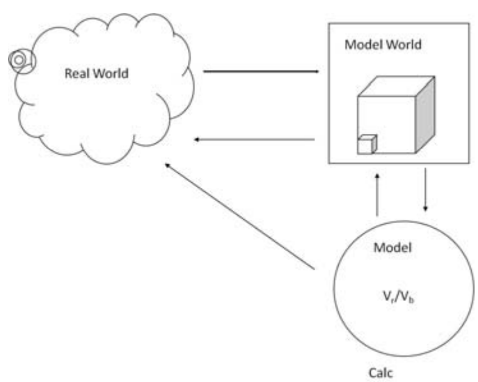
First Course Design Experience UMN – Institute of Technology

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



Problem-Based Learning





*Based on First Year Engineering course – Problem-based cooperative learning approach published in 1990.

Problem Based Cooperative Learning Format

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

INDIVIDUAL: Estimate answer. 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 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.

61

Cooperative Base Groups

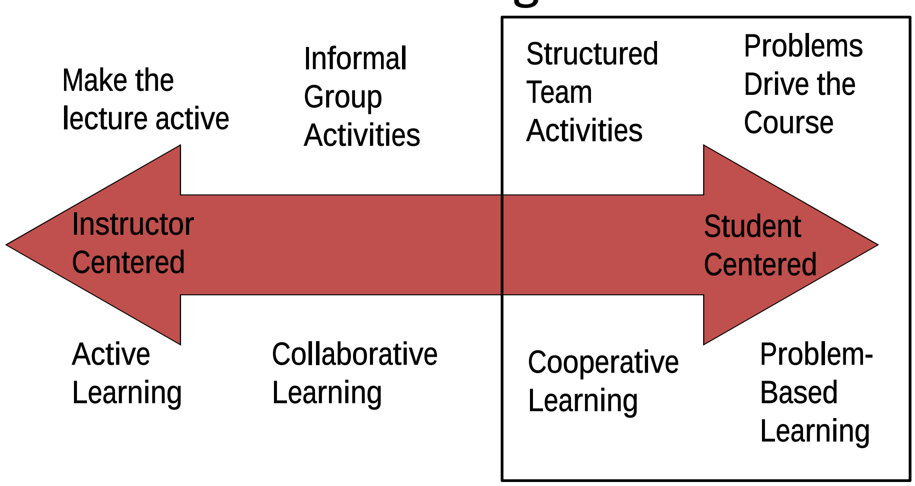
- Are Heterogeneous
- Are Long Term (at least one quarter or semester)
- Are Small (3-5 members)
- Are for support
- May meet at the beginning of each session or may meet between sessions
- Review for quizzes, tests, etc. together
- Share resources, references, etc. for individual projects
- Provide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

62

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 Active Learning Continuum



Prince, M. (2010). NAE FOEE

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

Design and Implementation of Cooperative Learning – Resources

- Design Framework – How People Learn (HPL) & Backward Design Process
  - Streveler, R.A., Smith, K.A. and Pilotte, M. 2011. Aligning Course Content, Assessment, and Delivery: Creating a Context for Outcome-Based Education – http://www.ce.umn.edu/~smith/links.html
  - Bransford, Vye & Bateman. 2002. Creating High Quality Learning Environments -- http://www.nap.edu/openbook/0309082927/html/
  - Pellegrino – Rethinking and redesigning curriculum, instruction and assessment: What contemporary research and theory suggests. http://www.skillscommission.org/commissioned.htm
  - Smith, K. A., Douglas, T. C., & Cox, M. 2009. Supportive teaching and learning strategies in STEM education. In R. Baldwin, (Ed.). Improving the climate for undergraduate teaching in STEM fields. New Directions for Teaching and Learning, 117, 19-32. San Francisco: Jossey-Bass.
- 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 - Instructional Format explanation and exercise to model format and to engage workshop participants
  - 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]
  - 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

65