Pedagogies of Engagement
Cooperative Learning and PBL

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Session 1-2 Layout

- Welcome & Overview
- Integrated Course Design (CAP Model)
  - Content
  - Assessment
  - Pedagogy
- Pedagogies of Engagement – Cooperative Learning
  - Informal – Bookends on a Class Session
  - Formal Cooperative Learning
    - Design and Teamwork Features
- Design and Implementation
Workshop Objectives

• Participants will be able to
  – Explain rationale for Pedagogies of Engagement, especially Cooperative Learning & PBL
  – Describe key features of Cooperative Learning
  – Apply cooperative learning to classroom practice
  – Describe key features of the Backward Design process – Content (outcomes) – Assessment - Pedagogy
  – Identify connections between cooperative learning and desired outcomes of courses and programs

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]
To adopt a systemic, research-based approach to innovation and continuous improvement of engineering education, recognizing the importance of diverse approaches—albeit characterized by quality and rigor—to serve the highly diverse technology needs of our society.


Integrated Course Design Model

- Aligning Course Content, Assessment, and Delivery: Creating a Context for Outcome-Based Education (Streveler, Smith & Pilotte, 2011)


- Curriculum-Instruction-Assessment Triad (Pellegrino, 2006)
“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)

Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology – National Science Foundation, 1996

Goal – All students have access to supportive, excellent undergraduate education in science, mathematics, engineering, and technology, and all students learn these subjects by direct experience with the methods and processes of inquiry.

Recommend that SME&T faculty: Believe and affirm that every student can learn, and model good practices that increase learning; starting with the student's experience, but have high expectations within a supportive climate; and build inquiry, a sense of wonder and the excitement of discovery, plus communication and teamwork, critical thinking, and life-long learning skills into learning experiences.
The Active Learning Continuum

- Make the lecture active
- Informal Group Activities
- Structured Team Activities
- Problems Drive the Course

- Instructor Centered
- Collaborative Learning
- Cooperative Learning
- Student Centered
- Problem-Based Learning

Prince, M. (2010). NAE FOEE

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

- Research – Randomized Design Field Experiments
- Practice – Formal Teams/Professor’s Role

Theory

Research

Practice

Cooperative Learning

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

[*First edition 1991]
Cooperative Learning Research Support

• 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

Small-Group Learning: Meta-analysis

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.
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).


Cooperative Learning Adopted
The American College Teacher:
National Norms for 2007-2008

<table>
<thead>
<tr>
<th>Methods Used in “All” or “Most”</th>
<th>All – 2005</th>
<th>All – 2008</th>
<th>Assistant - 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperative Learning</td>
<td>48</td>
<td>59</td>
<td>66</td>
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<tr>
<td>Group Projects</td>
<td>33</td>
<td>36</td>
<td>61</td>
</tr>
<tr>
<td>Grading on a curve</td>
<td>19</td>
<td>17</td>
<td>14</td>
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<tr>
<td>Term/research papers</td>
<td>35</td>
<td>44</td>
<td>47</td>
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http://www.heri.ucla.edu/index.php
Reflection and Dialogue

- Individually reflect on your familiarity with (1) Integrated Course Design and (2) Pedagogies of Engagement, especially Cooperative Learning.
  - 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

Designing Learning Environments Based on HPL (How People Learn)
Backward Design Approach
Wiggins & McTighe

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

Establishing Curricular Priorities

Related Integrated Course Design Model

Understanding by Design

Stage 1. Identify Desired Results

Filter 1. To what extent does the idea, topic, or process represent a big idea or having enduring value beyond the classroom?

Filter 2. To what extent does the idea, topic, or process reside at the heart of the discipline?

Filter 3. To what extent does the idea, topic, or process require uncoverage?

Filter 4. To what extent does the idea, topic, or process offer potential for engaging students?

Worksheet 1
Worksheet for Designing a Course/Class Session/Learning Module

<table>
<thead>
<tr>
<th>Learning Goals for Course/Session/Learning Module:</th>
<th>Ways of Assessing</th>
<th>Actual Teaching-Learning</th>
<th>Helpful Resources:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
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<td>(e.g., people, things)</td>
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<td>2.</td>
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<td>3.</td>
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<td>6.</td>
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</table>

27 28
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

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)
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
- Derive a kinetic model from experimental data

**Application.** Using abstractions in concrete situations *Determine, chart, implement, prepare, solve, use, develop*
- Using principles of operant conditioning, train a rat 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

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**The Cognitive Process Dimension**

<table>
<thead>
<tr>
<th>Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it.</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Knowledge of terminology</td>
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<tr>
<td>b. Knowledge of specific details and elements</td>
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</tbody>
</table>

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<tr>
<th>Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together.</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
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</thead>
<tbody>
<tr>
<td>a. Knowledge of classifications and categories</td>
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<td>b. Knowledge of principles and generalizations</td>
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<td>c. Knowledge of theories, models, and structures</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedural Knowledge – How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Knowledge of subject-specific skills and algorithms</td>
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<tr>
<td>b. Knowledge of subject-specific techniques and methods</td>
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<tr>
<td>c. Knowledge of criteria for determining when to use appropriate procedures</td>
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</tbody>
</table>

<table>
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<tr>
<th>Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one’s own cognition.</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
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</thead>
<tbody>
<tr>
<td>a. Strategic knowledge</td>
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<tr>
<td>b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge</td>
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<td>c. Self-knowledge</td>
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</tbody>
</table>

(Anderson & Krathwohl, 2001)
### The Cognitive Process Dimension

<table>
<thead>
<tr>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieving relevant knowledge from long-term memory</td>
<td>Determining the meaning of instructional messages, including oral, written, and graphic communication.</td>
<td>Carrying out or using a procedure in a given situation</td>
<td>Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose</td>
<td>Making judgments based on criteria and standards</td>
<td>Putting elements together to form a novel, coherent whole or make an original product</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recall</th>
<th>Restate</th>
<th>Employ</th>
<th>Distinguish</th>
<th>Select</th>
<th>Arrange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>Describe</td>
<td>Translate</td>
<td>Compare</td>
<td>Defend</td>
<td>Combine</td>
</tr>
<tr>
<td>Relate</td>
<td>Identify</td>
<td>Demonstrate</td>
<td>Contrast</td>
<td>Interpret</td>
<td>Combine</td>
</tr>
<tr>
<td>Review</td>
<td>Express</td>
<td>Examine</td>
<td>Deduce</td>
<td>Discriminate</td>
<td>Construct</td>
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<td></td>
<td>Propose</td>
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</table>

### Knowledge Dimension

#### 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
Facets of Understanding

When we truly understand, we

Can explain - cognitive
Can interpret - cognitive
Can apply - cognitive

Have perspective - affective
Can empathize - affective
Have self-knowledge - metacognitive

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Dee Fink - Creating Significant Learning Experiences

A TAXONOMY OF SIGNIFICANT LEARNING

1. Foundational Knowledge
   - "Understand and remember" learning
     For example: facts, terms, formulae, concepts, principles, etc.

2. Application
   - Thinking: critical, creative, practical (problem-solving, decision-making)
   - Other skills
     For example: communication, technology, foreign language
   - Managing complex projects

3. Integration
   - Making "connections" (i.e., finding similarities or interactions) . .
     Among: ideas, subjects, people

4. Human Dimensions
   - Learning about and changing one's SELF
   - Understanding and interacting with OTHERS

5. Caring
   - Identifying/changing one's feelings, interests, values

6. Learning How to Learn
   - Becoming a better student
   - Learning how to ask and answer questions
   - Becoming a self-directed learner
SOLO Taxonomy

- The **Structure of Observed Learning Outcome (SOLO)** model consists of 5 levels of understanding:
  - **Pre-structural** - The task is not attacked appropriately; the student hasn’t really understood the point and uses too simple a way of going about it.
  - **Uni-structural** - The student's response only focuses on one relevant aspect.
  - **Multi-structural** - The student's response focuses on several relevant aspects but they are treated independently and additively. Assessment of this level is primarily quantitative.
  - **Relational** - The different aspects have become integrated into a coherent whole. This level is what is normally meant by an adequate understanding of some topic.
  - **Extended abstract** - The previous integrated whole may be conceptualised at a higher level of abstraction and generalised to a new topic or area.


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?
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)

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
Book Ends on a Class Session

10-12 Minute Lecture
3-4 min. Turn to Partner
Vol. 1

3-4 min. Turn to Partner
Vol. 2

3-4 min. Turn to Partner
Vol. 3

5-6 Minute Summary
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.
Quick Thinks

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


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
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 . . .


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
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
  - 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

Harvard – Derek Bok Center
Richard Hake (Interactive engagement vs traditional methods)  
http://www.physics.indiana.edu/~hake/
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.
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
Session Summary
(Minute Paper)

Reflect on the session:

1. Most interesting, valuable, useful thing you learned.
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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)
Top Three Main Engineering Work Activities

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

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


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
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

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
Problem-Based Learning

START

Apply it

Problem posed

Learn it

Identify what we need to know

Problem-Based Cooperative Learning

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

http://web.mit.edu/edtech/casestudies/teal.html#video
Problem-Based Cooperative Learning

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http://www.ce.umn.edu/~smith

Estimation Exercise

First Course Design Experience
UMN – Institute of Technology

• Thinking Like an Engineer
• Problem Identification
• Problem Formulation
• Problem Representation
• Problem Solving
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.
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

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

Make the lecture active

Instructor Centered

Active Learning

Problem-Based Learning

Structured Team Activities

Collaborative Learning

Problems Drive the Course

Informal Group Activities

Cooperative Learning

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

• Content Resources

• Cooperative Learning - Instructional Format explanation and exercise to model format and to engage workshop participants
  – Cooperative Learning (Johnson, Johnson & Smith)
  – Smith web site –
  – Smith (2010) Social nature of learning: From small groups to learning communities. New Directions for Teaching and Learning, 2010, 123, 11-32 [ ]
  – Cooperative learning returns to college: What evidence is there that it works? Change, 1998, 30 (4), 26-35. [ ]

• Other Resources
  – University of Delaware PBL web site – www.udel.edu/pbl
  – PKAL – Pedagogies of Engagement –