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

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STEM Education Seminar
teaching & learning collaborative

The George Washington University
School of Engineering and Applied Science

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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
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

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]
Design Foundations

<table>
<thead>
<tr>
<th>Science of Instruction (UbD)</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>Good Theory/ Poor Practice</td>
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References:
- 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


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

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?


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Content-Assessment-Pedagogy (CAP) Design Process Flowchart

Backward Design

Start → Context

Content → Assessment → Pedagogy

C & A & P Alignment? → Yes → End

No → Are the desired results, assessments, and learning activities ALIGNED?

Backward Design

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UdB – 3 Stages of Backward Design

Identify the Desired Results

Determine Acceptable Evidence

Plan Learning Experiences

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

UbD Filters for Curricular Priorities

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

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

Reflection and Dialogue

• Individually reflect on your familiarity with (1) Integrated Course Design and (2) Pedagogies of 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
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
  – Frequent, Immediate, Discriminating, Lovingly 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)
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 wastewater treatment plant

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>
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<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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<tr>
<td>Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together.</td>
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<tr>
<td>a. Knowledge of classifications and categories</td>
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<tr>
<td>b. Knowledge of principles and generalizations</td>
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<tr>
<td>c. Knowledge of theories, models, and structures</td>
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<tr>
<td>Procedural Knowledge – How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.</td>
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<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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<tr>
<td>Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one’s own cognition.</td>
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<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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<tr>
<td>c. Self-knowledge</td>
</tr>
<tr>
<td>Remember</td>
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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)

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.
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 (3.2)
Q5 – Relevance: Little 1 . . . 5 Lots (3.9)
Q6 – Format: Ugh 1 . . . 5 Ah (4.0)

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 2012 – Session 2 (1/14/12)

Q4 – Pace: Too slow 1 . . . 5 Too fast (3.0)  
Q5 – Relevance: Little 1 . . . 5 Lots (3.5)  
Q6 – Discussion Control: Too Low 1 . . . 5 Too High (3.1)
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 ConceptTests - UW Madison
www.chem.wisc.edu/~concept
Video: Making Lectures Interactive with ConceptTests
   ModularChem Consortium – http://mc2.cchem.berkeley.edu/

STEMTEC

Harvard – Derek Bok Center

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)
The "Hake" Plot of FCI

Richard Hake (Interactive engagement vs traditional methods)
http://www.physics.indiana.edu/~hake/

Fig. 2. Histogram of the average normalized gain $<g>$; dark (red) bars show the fraction of 14 traditional courses ($N = 2064$), and light (green) bars show the fraction of 48 interactive engagement courses ($N = 4458$), both within bins of width $8\Delta g = 0.04$ centered on the $<g>$ values shown.
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
Active Learning: Cooperation in the College Classroom

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

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

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Formal Cooperative Learning Task Groups
### Top Three Main Engineering Work Activities

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

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

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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

Tom Friedman
Horizontalize Ourselves
CQ+PQ>IQ

AAC&U College Learning
For the New Global Century
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

Problem posed

Apply it

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

CAMBRIDGE, Mass. — For as long as anyone can remember, introductory physics at the Massachusetts Institute of Technology was taught in a vast windowsless amphitheater known by its number, 20-200. This year, however, the course will be taught in a high-tech environment, with 160 students using laptops and 360-degree video cameras to watch the lectures. The move reflects a larger trend in higher education toward smaller classes and hands-on learning.
http://mediamill.cla.umn.edu/mediamill/embed/78755


http://www.youtube.com/watch?v=lfT_hoiuY8w
http://youtu.be/lfT_hoiuY8w

http://www.udel.edu/inst/
Problem-Based Cooperative Learning

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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

Collaborative Learning

Student Centered

Structured Team Activities

Problems Drive the Course

Informal Group Activities

Cooperative Learning

Problem-Based 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
  - Pellegrino – Rethinking and redesigning curriculum, instruction and assessment: What contemporary research and theory suggests.
- 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, Sheppard, Johnson & Johnson (2005) Pedagogies of Engagement [Smith]
- Other Resources
  - University of Delaware PBL web site – www.udel.edu/pbl
  - PKAL – Pedagogies of Engagement –

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