The Active Learning Continuum

Make the lecture active

Instructor Centered

Active Learning

Informal Group Activities

Collaborative Learning

Structured Team Activities

Cooperative Learning

Problems Drive the Course

Problem-Based Learning

Student Centered

Prince, M. (2010). NAE FOEE

*My work is situated here – Cooperative Learning & Challenge-Based Learning
*My Engineering Education Innovation Story*

- 1972 – Materials Processing Research – University of Minnesota
- 1974 – First undergraduate teaching experience – “pour it in” model
- 1974-8 coursework in College of Education – Discovered cooperative learning (CL) about 1974 – Interdependence & Accountability resonated
- 1975 – Implemented CL in my classes
- 1981 – Went public with CL – JEE paper and FIE conference presentation
- 1980s – Continued refining CL in my classes, telling others & co-developed and co-taught Into Eng course – Building Models to Solve Engineering Problems based on CL
- 1990-1 – Sabbatical – wrote first draft of *Active Learning: Cooperation in the College Classroom* [David & Roger Johnson refined and 1st edition published in 1991]
- 1991 – Materials Processing Research lab closed as did undergrad & grad programs
- 1992 – present – continued to refine CL model in engineering and spread word
- 1998-2004 – Michigan State University - Senior Consultant to Provost for Faculty Development [part time appointment] – worked with faculty and grad students
- 2006 – Began phased retirement from University of Minnesota
- 2006 – present – Purdue School of Engineering Education PhD program
- 2010 – National Academy of Engineering Frontiers of Engineering Education Symposium

[*only model I knew when I started teaching*]
*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

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

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

Active and Cooperative Learning

Calls for evidence-based promising practices
How Clickers Work

By JACQUES STEINBERG

Published: November 15, 2010 At Northwestern University and on hundreds of other campuses, professors are arming students with hand-held clickers that look like a TV remote cross-bred with a calculator. Here is how they work:

1. Each clicker has a unique frequency that is assigned to a particular student.
2. Using a numbered keypad, students signal their responses to multiple-choice questions, which are tabulated wirelessly by the professor’s computer.
3. Polling software then collates the data and gives the professor the ability to create various graphs and reports instantly as well as to store the data for grading and other purposes.

Problem-Based Cooperative Learning

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

[Image of a classroom scene with students and a professor]

The Massachusetts Institute of Technology has changed the way it teaches some introductory courses. Prof. Gilbert Strang talks at a table to students and board.

By TALIA FLEET
Published: January 13, 2009

CAMBRIDGE, Mass. — For as long as anyone can remember, introductory physics at the Massachusetts Institute of Technology was taught to a vast audience: students known by their numbers.


http://web.mit.edu/edtech/casestudies/teal.html#video
### 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>
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<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>
</tr>
<tr>
<td>Term/research papers</td>
<td>35</td>
<td>44</td>
<td>47</td>
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</tbody>
</table>

http://www.heri.ucf.edu/index.php
*Innovation Stories*

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

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Innovation is the adoption of a new practice in a community

*We must focus on process of innovation*
1. What is the distribution of innovations?
2. Did it change over time? If so, how?
3. Where does your innovation fit?
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]

...objectives for engineering practice, research, and education:

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

Background Knowledge Survey

• Familiarity with
  – **Course Design Models**
    • Wiggins & McTighe – Understanding by Design (Backward Design)
    • Fink – Creating Significant Learning Experiences
    • Felder & Brent – Effective Course Design
  – **Research on Learning**
    • Models of Learning (Mayer, 2010)
      – Learning as response strengthening
      – Learning as information acquisition
      – Learning as knowledge construction
  • **How People Learn**
  • **Student Engagement**
    – National Survey of Student Engagement (NSSE)
    – CAEE APS APPLES (academic pathways of people learning engineering survey)
    – Cooperative learning

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Research can be inspired by ...

<table>
<thead>
<tr>
<th>Understanding (Basic)</th>
<th>Use (Applied)</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Pure basic research (Bohr)</td>
</tr>
<tr>
<td>No</td>
<td>Pure applied research (Edison)</td>
</tr>
</tbody>
</table>


Instructional Innovation can be based on..

<table>
<thead>
<tr>
<th>Science of Instruction (UbD)</th>
<th>Science of Learning (HPL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Good Theory/ Poor Practice</td>
</tr>
<tr>
<td>Yes</td>
<td>Good Theory &amp; Good Practice</td>
</tr>
</tbody>
</table>

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 students 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.

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
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?

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

Understanding by Design, pp. 10-11

STOP and Think

Revisit your engineering education innovation. Is your innovation based on HPL framework or other Learning Theory? How does your approach compare with the Understanding by Design (backward design) process?
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)
Changes to Bloom’s

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

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

- Individually reflect on your Engineering Education Innovation. Write for about 1 minute
  - Are the student learning outcomes clearly articulated?
    - Are they BIG ideas at the heart of the discipline?
  - Are the assessments aligned with the outcomes?
  - Is the pedagogy aligned with the outcomes & assessment?

- Discuss with your neighbor for about 3 minutes
  - Select Design Example, Comment, Insight, etc. that you would like to present to the whole group if you are randomly selected

The biggest and most long-lasting reforms of undergraduate education will come when individual faculty or small groups of instructors adopt the view of themselves as reformers within their immediate sphere of influence, the classes they teach every day.

K. Patricia Cross
Resources

- **Learning**

- **Design Framework – How People Learn (HPL) & Understanding by Design Process**

- **Other Resources**
  - University of Delaware PBL web site – [www.udel.edu/pbl](http://www.udel.edu/pbl)

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- Symposium materials are posted on
  - [http://www.ce.umn.edu/~smith/links.html](http://www.ce.umn.edu/~smith/links.html)
  - CLEERhub.org