Opportunities and Challenges in First-Year Engineering (FYE) Programs

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ASEE North Midwest Section Meeting
Luncheon
October 18, 2013

Reflection and Dialogue

• Individually reflect on FYE. Write for about 1 minute
  – What are the purposes of FYE programs?
  – What are the most important outcomes for FYE programs?
  – What are promising approaches for achieving the desired outcomes?

• Discuss with your neighbor for about 2 minutes
  – Select a comment that you would like to present to the whole group if you are randomly selected
Defining “Engineer”

• What knowledge and skills are essential?
• What are the ways of knowing and habits of mind?
• What does it mean to be an engineer?

Carnegie Preparation for the Professions Project

http://www.carnegiefoundation.org/publications/educating-engineers-designing-future-field
History of the term “engineer”

The term *engineer* is derived from the French term *ingénieur*. Vitruvius, author of *De Architecture*, written in about 20 B.C.E. wrote in the introduction that master builders were ingenious, or possessed *ingenium*. From the eleventh century, master builders were called *ingeniator* (in Latin), which through the French, *ingénieur*, became the English *engineer* (Auyang, 2004).


Definitions (OED)

- **Technology** –
  - systematic treatment of art, craft
  - Sanskrit term
- **Engineering** –
  - The action of the verb [*ENGINEER*; the work done by, or the profession of, an engineer
  - Code of Hammurabi (1700 BCE)
- **Smith** –
  - One who works in iron or other metal
  - Original sense – craftsman, skilled worker in metal, wood or other material
Technology

Three definitions of technology (Arthur, 2009)
1. A means to fulfill a human purpose
2. An assemblage of practices and components
3. The entire collection of devices and engineering practices available to a culture

Three fundamental principles (Arthur, 2009):
1. All technologies are combinations
2. Each component of technology is itself in miniature a technology
3. All technologies harness and exploit some effect or phenomena, usually several

Engineering According to ABET

The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind
Engineering

A scientist discovers that which exists. An engineer creates that which never was -- Theodore von Kármán (1881-1963)

The engineering method is design under constraints – Wm. Wulf, Past President, National Academy of Engineering

Engineering

The engineering method is the use of heuristics to cause the best change in a poorly understood situation within the available resources – Billy Koen, Discussion of the Method (2003)

The engineering method (design) is the use of state-of-the-art heuristics to create the best change in an uncertain situation within the available resources. Billy Koen, 2011
Engineering = Design

Design in a major sense is the essence of engineering; it begins with the identification of a need and ends with a product or system in the hands of a user. It is primarily concerned with synthesis rather than the analysis which is central to engineering science. Design, above all else, distinguishes engineering from science (Hancock, 1986, National Science Foundation Workshop).


Engineering Design

*Engineering design* is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specified set of constraints.

Skills often associated with good designers – the ability to:

- tolerate ambiguity that shows up in viewing design as inquiry or as an iterative loop of divergent-convergent thinking;
- maintain sight of the big picture by including systems thinking and systems design;
- handle uncertainty;
- make decisions;
- think as part of a team in a social process; and
- think and communicate in the several languages of design.

An Engineer’s Dilemma

*Engineers are always confronted with two ideals, efficiency and economy, and the world’s best computer could not tell them how to reconcile the two. There is never “one best way.” Like doctors or politicians or poets, engineers face a vast array of choices every time they begin work, and every design is subject to criticism and compromise.*

Where do we Learn About Engineering?

• K-12
  – Next Generation Science Standards
    • http://www.nextgenscience.org/next-generation-science-standards
  – National Academy of Engineering
    • http://www.nae.edu/Programs/TechLit1/K12stds.aspx

• Engineers
  – Engineering Professional Organizations, e.g., ABET, NAE
  – Researchers – Bucciarelli, Koen, etc.

• Ethnographers (who may or may not be engineers)
  – Barley, Orr, Perlow, etc.

• Writers
  – Kidder – *Soul of a new machine*

• Popular Media
  – "Houston, we’ve got a problem."
  – McGyver?
  – Star Trek?

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A Framework for Implementing Quality K-12 Engineering Education

CAREER: Implementing K-12 Engineering Standards through STEM Integration

PI: Tamara J. Moore, University of Minnesota
	tmmoore@umn.edu | 612-624-1518

Graduate Researchers: Krysta M. Tark, Arin W. Gracy, Jennifer A. Kersten, Michael B. Stahlman, Farzad Now, Mohamed Ruzairah

Definition of Engineering

Throughout this introduction and framework we define engineering to be the design, manufacture, and operation of efficient and economical technologies (i.e., structures, machines, processes, and systems) to purposeful ends through a creative and carefully planned application of scientific and mathematical principles.

Purpose and Intended Use of the K-12 Framework for Engineering

This framework was created to meet the growing need for a clear definition of quality K-12 engineering education. It is the result of a research project focused on understanding and identifying the ways in which teachers and schools implement engineering and engineering design in their classrooms. The framework is designed to be used as a tool for evaluating the degree to which academic standards, curricula, and teaching practices address the important components of a quality K-12 engineering education. Additionally, this framework can be used to inform the development and structure of future K-12 engineering education initiatives and related standards.

Development of the K-12 Framework for Engineering

The framework's key indicators for a quality K-12 engineering education were determined based on an extensive review of the literature, established criteria for undergraduate and professional organizations, and in consultation with experts in the field.

http://www.asee.org/public/conferences/20/papers/7043/view
Engineering in Popular Media

- "Houston, we've got a problem." Apollo 13
- MacGyver?
- Myth Busters?
- Petroski
- Dilbert
Dilbert – The Knack

http://www.youtube.com/watch?v=CmYDgncMhXw

Changing the Conversation
Successful Attributes for the Engineer of 2020

- Analytical skills
- Practical ingenuity
- Creativity
- Communication & teamwork skills
- Business & management skills
- High ethical standards
- Professionalism
- Leadership, including bridging public policy and technology
- Dynamism/agility/resilience/flexibility
- Lifelong learners

http://www.nae.edu/Programs/Education/Activities10374/Engineerof2020.aspx
1. a shift from hands-on and practical emphasis to engineering science and analytical emphasis;
2. a shift to outcomes-based education and accreditation;
3. a shift to emphasizing engineering design;
4. a shift to applying education, learning, and social-behavioral sciences research;
5. a shift to integrating information, computational, and communications technology in education.

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&tp=&amnumber=6185632

Engineering Education: Advancing the Practice
Karl Smith

Research
• Learning ~1974
• Design ~1995
• Engineering Education Research & Innovation ~ 2000
• STEM Education ~ 2010

Innovation – Cooperative Learning
• Need identified ~1974
• Introduced ~1976
• FIE conference 1981
• JEE paper 1981
• Research book 1991
• Practice handbook 1991
• Change paper 1998
• Teamwork and project management 2000
• JEE paper 2005

Innovation is the adoption of a new practice in a community - Denning & Dunham (2010)

Process Metallurgy

- Dissolution Kinetics – liquid-solid interface
- Iron Ore Desliming – solid-solid interface
- Metal-oxide reduction roasting – gas-solid interface
Dissolution Kinetics

- Theory – Governing Equation for Mass Transport
- Research – rotating disk
- Practice – leaching of silver bearing metallic copper & printed circuit-board waste

\[(\nabla c \cdot \vec{v}) = D \nabla^2 c\]

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

First Teaching Experience

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

- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics
- Research – ?
- Theory – ?
University of Minnesota College of Education
Social, Psychological and Philosophical Foundations of Education

• Statistics, Measurement, Research Methodology
• Assessment and Evaluation
• Learning and Cognitive Psychology
• Knowledge Acquisition, Artificial Intelligence, Expert Systems
• Development Theories
• Motivation Theories
• Social psychology of learning – student – student interaction

Lila M. Smith
Cooperative Learning

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

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 Introduced to Engineering – 1981


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
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)

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>
</tr>
<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>
</tr>
</tbody>
</table>

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

Undergraduate Teaching Faculty, 2011*

<table>
<thead>
<tr>
<th>Methods Used in “All” or “Most”</th>
<th>STEM women</th>
<th>STEM men</th>
<th>All other women</th>
<th>All other men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperative learning</td>
<td>60%</td>
<td>41%</td>
<td>72%</td>
<td>53%</td>
</tr>
<tr>
<td>Group projects</td>
<td>36%</td>
<td>27%</td>
<td>38%</td>
<td>29%</td>
</tr>
<tr>
<td>Grading on a curve</td>
<td>17%</td>
<td>31%</td>
<td>10%</td>
<td>16%</td>
</tr>
<tr>
<td>Student inquiry</td>
<td>43%</td>
<td>33%</td>
<td>54%</td>
<td>47%</td>
</tr>
<tr>
<td>Extensive lecturing</td>
<td>50%</td>
<td>70%</td>
<td>29%</td>
<td>44%</td>
</tr>
</tbody>
</table>

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).


First Course Design Experience
UMN – Institute of Technology

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

Problem-Based Learning
Problem-Based Learning

Problem posed
Identify what we need to know
Learn it
Apply it
START

Real World

Model World

Model

Calc

\[ V_r/V_b \]
Fundamentals of Engineering Education Research

Rigorous Research in Engineering Education Initiative
(NSF DUE 0817461)
CLEERhub.org

Faculty Development Workshop (2013) – January 9, 2013 – Jeju Island, South Korea

Ruth A. Streveler
Purdue University

Karl A. Smith
Purdue University and University of Minnesota

Discipline-Based Education Research: Findings and Implications

King Fahd University of Petroleum and Minerals – August 19, 2013 – Saudi Arabia

Karl A. Smith
Purdue University and University of Minnesota
Levels of inquiry in engineering education

• **Level 0** Teacher
  – Teach as taught

• **Level 1** Effective Teacher
  – Teach using accepted teaching theories and practices

• **Level 2** Scholarly Teacher
  – Assesses performance and makes improvements

• **Level 3** Scholar of Teaching and Learning
  – Engages in educational experimentation, shares results

• **Level 4** Engineering Education Researcher
  – Conducts educational research, publishes archival papers


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Discipline-Based Education Research (DBER)

Understanding and Improving Learning in Undergraduate Science and Engineering

http://www.nap.edu/catalog.php?record_id=13362
Study Charge

• Synthesize empirical research on undergraduate teaching and learning in physics, chemistry, engineering, biology, the geosciences, and astronomy.

• Examine the extent to which this research currently influences undergraduate science instruction.

• Describe the intellectual and material resources that are required to further develop DBER.

Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research

• SUSAN SINGER (Chair), Carleton College
• ROBERT BEICHNER, North Carolina State University
• STACEY LOWERY BRETZ, Miami University
• MELANIE COOPER, Clemson University
• SEAN DECATUR, Oberlin College
• JAMES FAIRWEATHER, Michigan State University
• KENNETH HELLER, University of Minnesota
• KIM KASTENS, Columbia University
• MICHAEL MARTINEZ, University of California, Irvine
• DAVID MOGK, Montana State University
• LAURA R. NOVICK, Vanderbilt University
• MARCY OSGOOD, University of New Mexico
• TIMOTHY F. SLATER, University of Wyoming
• KARL A. SMITH, University of Minnesota and Purdue University
• WILLIAM B. WOOD, University of Colorado
“It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments.”

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

Course Design Foundations

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

How People Learn (HPL)

- 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

Understanding by Design (UbD)

- Stage 1. Identify Desired Results
  - Enduring understanding (enduring outcomes)
  - 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 vs. Engineering Design

Identify the Desired Results

Determine Acceptable Evidence

Plan Learning Experiences

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

Determine requirements/specifications

Develop or use established metrics to measure against outcomes

Plan and develop process, system, etc. to implement

Streveler and Smith 55

References:

- Bransford, Vye and Bateman – Creating High Quality Learning Environments
Revised Bloom’s Learning Taxonomy

A statement of a learning objective contains a verb (an action) and an object (usually a noun).

- The verb generally refers to a concept associated with the intended cognitive process.
- The object generally describes the knowledge students are expected to acquire or construct (Anderson and Krathwohl, 2001, pp. 4-5).

In this model, each of the colored blocks shows an example of a learning objective that generally corresponds with each of the various combinations of the cognitive process and knowledge dimensions.

Remember: there are learning objectives—not learning activities. It may be useful to think of presenting each objective with something like: “Students will be able to…”


Interactive Learning Continuum

Make the lecture active
Instructor Centered

Active Learning

Collaborative Learning

Informal Group Activities

Structured Team Activities

Problems Drive the Course

Student Centered

Formal Cooperative Learning

Problem-Based Learning

Prince, M. (2010). NAE FOEE

Strong Evidence Base – Cooperative Learning & Challenge-Based Learning
Informal Cooperative Learning

Active Learning: Cooperation in the College Classroom

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

See Cooperative Learning Handout (CL College-912.doc)
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?
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

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

**Physics**
- Peer Instruction
  - Peer Instruction – [www.prenhall.com](http://www.prenhall.com)

**Chemistry**
- Chemistry ConcepTests - UW Madison
  - [www.chem.wisc.edu/~concept](http://www.chem.wisc.edu/~concept)

**Video:** Making Lectures Interactive with ConcepTests

**STEMTEC**

**Harvard – Derek Bok Center**
Thinking Together & From Questions to Concepts: Interactive Teaching in Physics
- [www.fas.harvard.edu/~bok_cen/](http://www.fas.harvard.edu/~bok_cen/)
University of Minnesota Collaborative Model
for Large Introductory Courses

University of MN, Physics Education Research and Development, 1996
http://groups.physics.umn.edu/physed/Research/MNModel/Model.html

Conceptual Understanding

http://groups.physics.umn.edu/physed/Research/MNModel/FCI.html
Physics (Mechanics) Concepts: The Force Concept Inventory (FCI)

- A 30 item multiple choice test to probe student’s understanding of basic concepts in mechanics.
- The choice of topics is based on careful thought about what the fundamental issues and concepts are in Newtonian dynamics.
- Uses common speech rather than cueing specific physics principles.
- The distractors (wrong answers) are based on students' common inferences.

Workshop Biology

Traditional passive lecture vs. “Workshop biology”

Source: Udovic et al. 2002
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-912.doc)
Design team failure is usually due to failed team dynamics (Leifer, Koseff & Lenshow, 1995).

It’s the soft stuff that’s hard, the hard stuff is easy (Doug Wilde, quoted in Leifer, 1997)

Professional Skills

Most Important Skills Employers Look For In New Hires

Which TWO of the following skills or abilities are most important to you? 

<table>
<thead>
<tr>
<th>Skill/Franchise</th>
<th>Recent Grade*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teamwork skills</td>
<td>44%</td>
</tr>
<tr>
<td>Critical thinking</td>
<td>33%</td>
</tr>
<tr>
<td>Oral/written communication</td>
<td>30%</td>
</tr>
<tr>
<td>Ability to assemble/organize information</td>
<td>21%</td>
</tr>
<tr>
<td>Innovative thinking</td>
<td>20%</td>
</tr>
<tr>
<td>Able to work with numbers/statistics</td>
<td>10%</td>
</tr>
<tr>
<td>Foreign language proficiency</td>
<td>6%</td>
</tr>
</tbody>
</table>

* Skills/abilities recent graduates think are the two most important to employers

Top Three Main Engineering Work Activities

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

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


www.mhhe.com/smithteamwork4e
Characteristics of Effective Teams?

-?

•?

A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable

- SMALL NUMBER
- COMPLEMENTARY SKILLS
- COMMON PURPOSE & PERFORMANCE GOALS
- COMMON APPROACH
- MUTUAL ACCOUNTABILITY

--Katzenbach & Smith (1993)
*The Wisdom of Teams*
Cooperative Learning is instruction that involves people working in teams to accomplish a common goal, under conditions that involve both positive interdependence (all members must cooperate to complete the task) and individual and group accountability (each member is accountable for the complete final outcome).

Key Concepts

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


Teamwork Skills

• Communication
  • Listening and Persuading
• Decision Making
• Conflict Management
• Leadership
• Trust and Loyalty
Instructor'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

Decisions, Decisions

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

7. **Group Tests**

Cooperative Jigsaw

**JIGSAW SCHEDULE**

**COOPERATIVE GROUPS (3-4 members)**

**PREPARATION PAIRS**

**CONSULTING/SHARING PAIRS**

**TEACHING/LEARNING IN COOPERATIVE GROUPS**

**WHOLE CLASS REVIEW**

www.jigsaw.org/
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 Controversy
7. **Group Tests**

Problem Based Cooperative Learning Format

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

**INDIVIDUAL:** Develop ideas, Initial Model, Estimate, etc. Note strategy.

**COOPERATIVE:** One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to solve each problem.

**EXPECTED CRITERIA FOR SUCCESS:** Everyone must be able to explain the model and strategies used to solve each problem.

**EVALUATION:** Best answer within available resources or constraints.

**INDIVIDUAL ACCOUNTABILITY:** One member from your group may be randomly chosen to explain (a) the answer and (b) how to solve each problem.

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

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

Problem posed

Identify what we need to know

Learn it

Apply it

START

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 front windowless amphitheater known by its number,
http://web.mit.edu/edtech/casestudies/teal.html#video

http://www.ncsu.edu/PER/scaleup.html
Inside an Active Learning Classroom

- STSS at the University of Minnesota
  http://vimeo.com/andyub/activeclassroom

“I love this space! It makes me feel appreciated as a student, and I feel intellectually invigorated when I work and learn in it.”
http://tile.uiowa.edu/

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

PBL Training at a lower cost: Attend our January 4 & Workshop for an Introduction to PBL.

*This workshop will demonstrate problem-based learning (PBL) and model ways that PBL can be used effectively in all disciplines. We will begin with a problem and participants will work in teams to experience first-hand what the instructional approach entails. We will then move to the main focus of the program: writing effective problem-based materials. Participants will leave the session with new or revised problems for use in their courses.*
Active Learning: Cooperation in the College Classroom

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

See Cooperative Learning Handout (CL College-912.doc)

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
## Does Psychological Safety Hinder Performance?

Psychological safety does not operate at the expense of employee accountability; the most effective organizations achieve high levels of both, as this matrix shows.

### Accountability for Meeting Demanding Goals

<table>
<thead>
<tr>
<th></th>
<th>LOW</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Psychological Safety</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Comfort zone</strong></td>
<td>Employees really enjoy working with one another but don’t feel particularly challenged. Nor do they work very hard. Some family businesses and small consultancies fall into this quadrant.</td>
<td></td>
</tr>
<tr>
<td><strong>Apathy zone</strong></td>
<td>Employees tend to be apathetic and spend their time jockeying for position. Typical organizations in this quadrant are large, top-heavy bureaucracies, where people fulfill their functions but the preferred modus operandi is to curry favor rather than to share ideas.</td>
<td></td>
</tr>
<tr>
<td><strong>Anxiety zone</strong></td>
<td>Such firms are breeding grounds for anxiety. People fear to offer tentative ideas, try new things, or ask colleagues for help, even though they know great work requires all three. Some investment banks and high-powered consultancies fall into this quadrant.</td>
<td></td>
</tr>
</tbody>
</table>

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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
Discipline-Based Education Research (DBER)

- Discipline-based education research (DBER) is a small but growing field of inquiry.
- Conducting DBER and using DBER findings are distinct but interdependent pursuits.
- DBER is inherently interdisciplinary.
- Individual fields of DBER have made notable inroads in terms of establishing their fields but still face challenges in doing so.
- Blending a scientific/engineering discipline with education research poses unique professional challenges for DBER scholars.
- There are many pathways to becoming a discipline-based education researcher.

Discipline-Based Education Research Timeline

- Engr. Sci. Reform
- Curricula Reform
- EC2000
- EER
- Geoscience
- Biology ER
- Curricula Reform
- Chemistry ER
- Curricula Reform
- Physics ER
- Medical ER

DBER is located in the relevant disciplinary school, e.g. medicine, physics.
Discipline-Based Education Research (DBER) Report Update

National Research Council

Journal of Engineering Education
Editorial – October, 2013

Workshop: I-Corps for Learning (I-Corps-L):
A Pilot Initiative to Propagate & Scale Educational Innovations
(NSF DUE)

1. Give the I-Corps-L team an experiential learning opportunity to help determine the readiness of their innovation for sustainable scalability. Sustainable scalability involves a self-supported entity that is sustainable and systematically promotes the adoption of the educational innovation and enables and facilitates its use.

2. Enable the team to develop a clear go/no go decision regarding sustainable scalability of the innovation.

3. Develop a transition plan and actionable tasks to move the innovation forward to sustainable scalability, if the team decides to do so.

Instructor Team: Karl Smith (PI), Ann McKenna & Chris Swan
Education Innovation

• 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

• We can’t wait 25 years for YOUR innovations to become widely practiced!

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The Instructor’s Role in Cooperative Learning

Make Pre-instructional Decisions

- Specify learning objectives: Clarify the goals of the learning activity to ensure students understand the expected outcomes.
- Assign group roles: Clearly define the roles each group member will assume to promote collaboration and accountability.
- Prepare group activities: Design activities that require interaction and discussion to facilitate learning.
- Assign group members:
  - Sort students by major or career goals to promote diversity in group dynamics.
  - Pair students to encourage cross-disciplinary interaction.

Assign and Distribute

- Assign roles to groups: Ensure each group has a leader and a scribe to maintain organization and record group discussions.
- Divide tasks among group members: Allocate responsibilities to ensure equal participation and workload distribution.

Monitor and Intervene

- Monitor student learning: Regularly assess students’ understanding and progress throughout the cooperative learning process.
- Monitor group dynamics: Observe group interactions to ensure effective communication and collaboration.

Evaluate and Process

- Evaluate student learning: Assess students’ understanding of the material through quizzes, tests, or projects.
- Evaluate group performance: Evaluate groups’ contributions, accountability, and overall effectiveness.

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## Resources

- **Design Framework** – How People Learn (HPL) & Understanding by Design (UdB) Process
- **Content Resources**
- **Cooperative Learning**
  - Cooperative Learning (Johnson, Johnson & Smith) - Smith web site – [www.ce.umn.edu/~smith](http://www.ce.umn.edu/~smith)
- **Other Resources**
  - University of Delaware PBL web site – [www.udel.edu/pbl](http://www.udel.edu/pbl)
Reflection and Dialogue

• Individually reflect on your FYE program. 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?
  – Are you emphasizing innovation and teamwork?

• Discuss with your neighbor for about 2 minutes
  – Select Design Example, Comment, Insight, etc. that you would like to present to the whole group if you are randomly selected