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

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

ASEE North Midwest Section Meeting

Luncheon

October 18, 2013

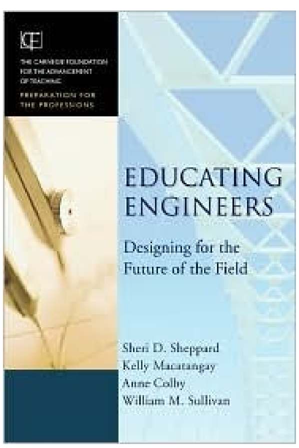
Reflection and Dialogue

- 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"

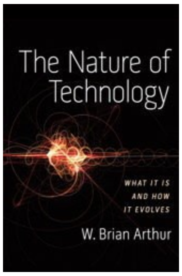
The term *engineer* is derived from the French term *ingénieur.* Vitruvius, author of *De Architecture*, written in about 20 B.C.E. wrote in the introduction that master builders were ingenious, or possessed *ingenium*. From the eleventh century, master builders were called *ingeniator* (in Latin), which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

Auyang, S.Y. 2004. *Engineering – an endless frontier*. Cambridge, MA: Harvard University Press.

Definitions (OED)

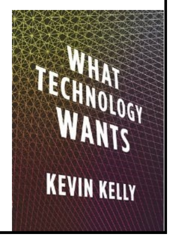
- Technology –
  - systematic treatment of art, craft
  - Sanskrit term
- Engineering –
  - The action of the verb ENGINEER; the work done by, or the profession of, an engineer
  - Code of Hammurabi (1700 BCE)
- Smith –
  - One who works in iron or other metal
  - Original sense – craftsman, skilled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

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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

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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).

Design defines engineering. It's an engineer's job to create new things to improve society. It's the University's obligation to give students fundamental education in design (William Durfee, ME, U of Minnesota, *Minnesota Technolog*, Nov/Dec 1994).

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.

Engineering Design Thinking, Teaching, and Learning -- http://www.asee.org/about/publications/jee/upload/2005jee_sample.htm

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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.

Engineering Design Thinking, Teaching, and Learning -- http://www.asee.org/about/publications/jee/upload/2005jee_sample.htm

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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.

Source: Billington, D.P., 1986, "In defense of engineers," *The Wilson Quarterly,* January.

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?

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
tamara@umn.edu | 612-624-1516

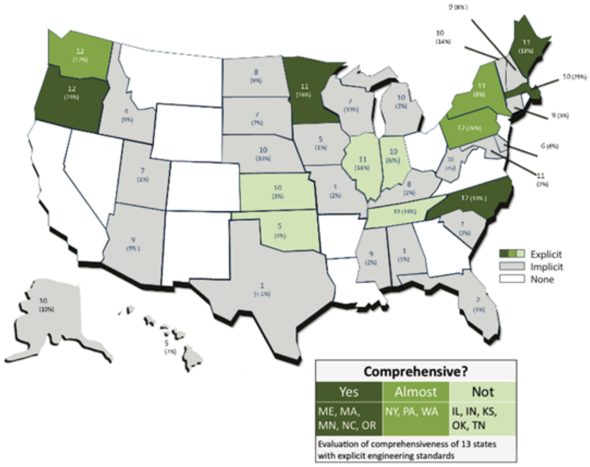
Graduate Researchers: Kristina M. Tank, Aran W. Glancy, Jennifer A. Kersten, Micah S. Stohlmann, Forster Ntow, Mohammed Rizkallah

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 criterion for undergraduate and professional organizations, and in consultation with experts in the

http://www.asee.org/public/conferences/20/papers/7043/view



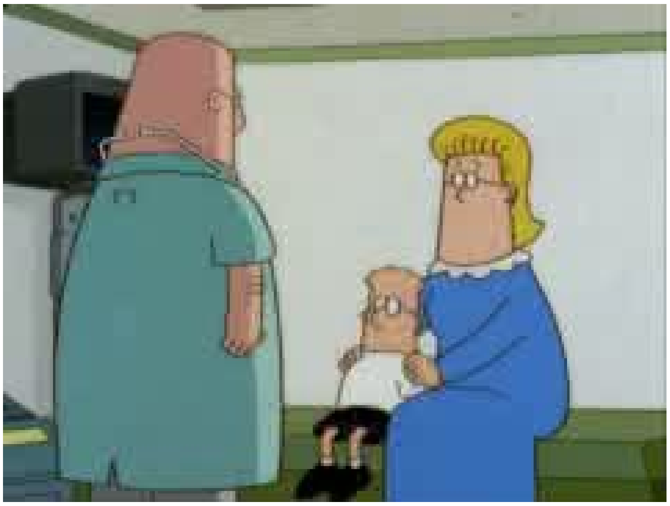
The Distribution of Engineering Presented in State Science Standards

Distribution of Engineering-Related Codes Across Grade Bands

Engineering in Popular Media

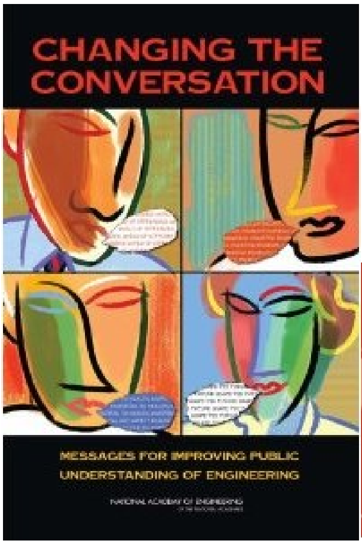
- "Houston, we've got a problem." Apollo 13
- MacGyver?
- Myth Busters?
- Petroski
- Dilbert

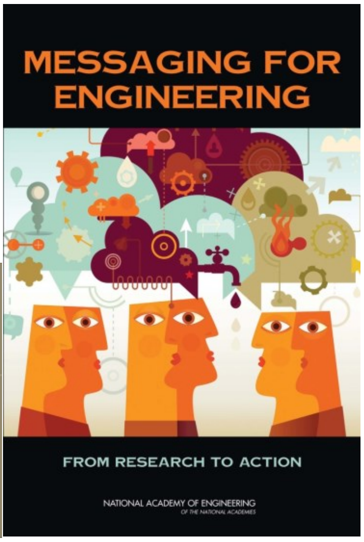
Dilbert – The Knack



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

Purdue's Future Engineer

Vision: Purdue Engineers will be prepared for leadership roles in responding to the global technological, economic, and societal challenges of the 21st century.

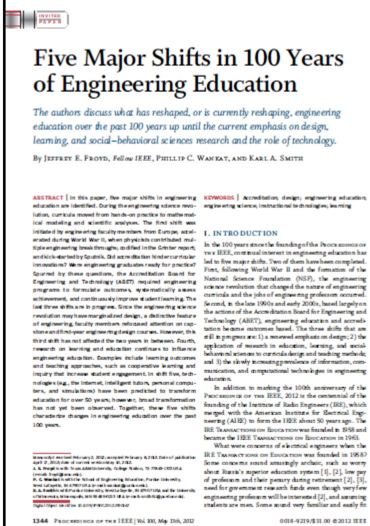
Strategy: We will provide educational experiences that develop students' knowledge areas, abilities, and qualities to enable them to identify needs and construct effective solutions in an economically, socially, and culturally relevant manner.

Abilities
- leadership
- teamwork
- communication
- decision-making
- recognize & manage change
- work effectively in diverse & multicultural environments
- work effectively in the global engineering profession
- synthesize engineering, business, and societal perspectives

Knowledge Areas
- science & math
- engineering fundamentals
- analytical skills
- open-ended design & problem solving skills
- multidisciplinarity within and beyond engineering
- integration of analytical, problem solving, and design skills

Qualities
- innovative
- strong work ethic
- ethically responsible in a global, social, intellectual, and technological context
- adaptable in a changing environment
- entrepreneurial and intrapreneurial
- curious and persistent continuous learners

The Three Pillars of the Purdue Engineering Undergraduate Education


INVITED PAPER

Five Major Shifts in 100 Years of Engineering Education

The authors discuss what has reshaped, or is currently reshaping, engineering education over the past 100 years up until the current emphasis on design, learning, and social–behavioral sciences research and the role of technology.

By Jeffrey E. Froyd, *Fellow IEEE*, Phillip C. Wankat, and Karl A. Smith

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.

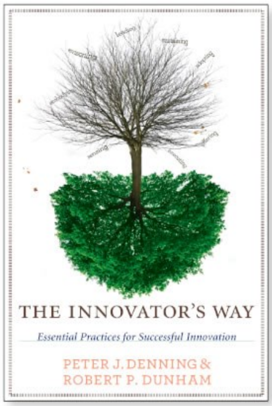
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&tp=&arnumber=6185632

Engineering Education: Advancing the Practice
Karl Smith

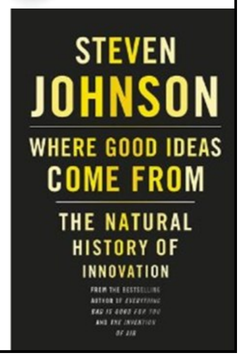
Research
•Process Metallurgy 1970 -1992
•Learning ~1974
•Design ~1995
•Engineering Education Research & Innovation ~ 2000
•STEM Education ~ 2010

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

National Academy of Engineering - Frontiers of Engineering Education Symposium - December 13-16, 2010 - Slides PDF [Smith-NAE-FOEE-HPL-UbD-12-10-v8.pdf]



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

$$(\nabla c \bullet \underline{v}) = D\nabla^2 c$$

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

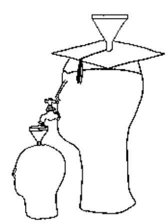
First Teaching Experience

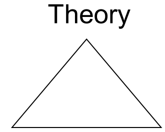
- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics

Lila M. Smith

Engineering Education

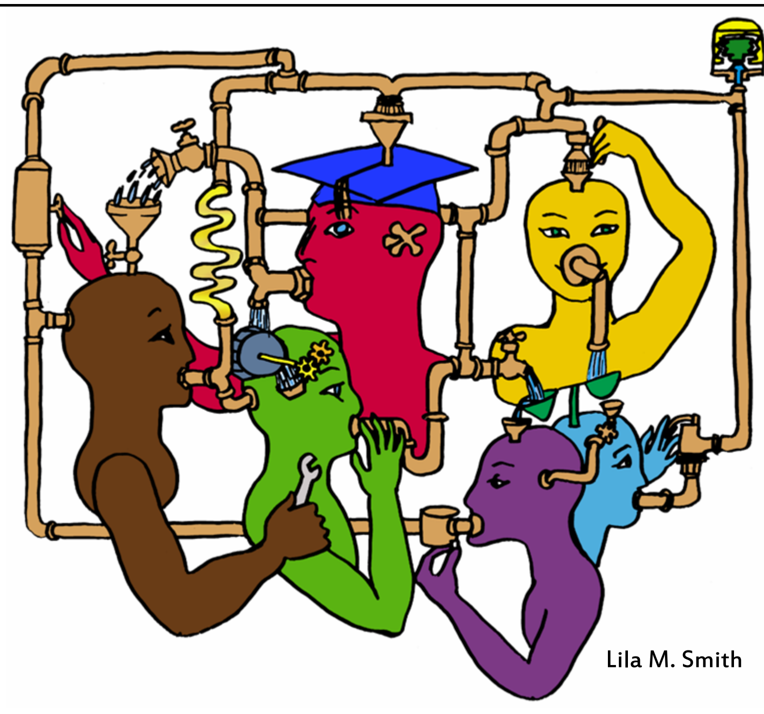
- Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics
- Research – ?
- Theory – ?





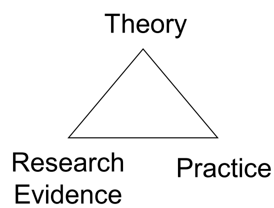
University of Minnesota College of Education
Social, Psychological and Philosophical
Foundations of Education

- 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



Cooperative Learning

- Theory – Social Interdependence – Lewin – Deutsch – Johnson & Johnson
- 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

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

Cooperative Learning Introduced to Engineering – 1981

- Smith, K.A., Johnson, D.W. and Johnson, R.T., 1981. The use of cooperative learning groups in engineering education. In L.P. Grayson and J.M. Biedenbach (Eds.), *Proceedings Eleventh Annual Frontiers in Education Conference*, Rapid City, SD, Washington: IEEE/ASEE, 26-32.

Structuring Learning Goals To Meet the Goals of Engineering Education

Karl A. Smith,
David W. Johnson, and Roger T. Johnson
University of Minnesota

The growing concern about engineering education in the United States has been the subject of many recent editorials and articles.* They point to the deteriorating quality of engineering and science education, the lack of adequate preparation in mathematics and science on the part of high school graduates, the shortage of engineers, and, especially, the shortage of college teachers of engineering. Unless corrective measures are taken, it may be more difficult in the coming years to achieve the goals of engineering education and to meet the needs of engineering students.

Goals of Engineering Education

The three major goals of engineering education are to promote technological, interpersonal, and social-technical competencies in engineering students. The achievement of *technological competence* requires the mastery and retention of science and engineering facts, principles, theories and analytical skills; the development of synthesis, design, modeling and problem solving skills; and the development of implementation skills for converting knowledge into action.

Interpersonal competence requires the development of the cognitive, affective and behavioral prerequisites for working with others to perform a task.[1] Among the skills required are communication, constructive conflict management, interpersonal problem solving, joint decision making and perspective-taking skills. Interpersonal competence is becoming increasingly important for engineers due to the tremendous technical complexity and the societal constraints of most problems. Engineers must now, more than ever, work with other engineers and scientists, economists, educators, consumer groups, and government regulatory agencies to reach satisfactory and mutually acceptable designs for future technology.

Social-technical competence requires gaining an understanding of the complex interdependencies between technology and society, of the influence of technology on individual and collective behavior and on the natural environment. Essentially, social-technical competence involves perspective-taking on a large scale that encompasses historical, social, psychological, and philosophical viewpoints, as well as an understanding of the basic premises underlying the interaction between society and technology.

Needs of Engineering Graduates

Many studies have been conducted on engineering education since it began at West Point in 1792, and these have been well summarized.[2] The earliest study (by Mann in 1918) called for a return to the basics; each of the subsequent ones emphasized diversity and a broad education,[3] and their general findings have been summarized by Cheit[4] in the following three statements:

1) There is renewed concern that, despite many efforts, engineering education is not yet incorporating what is called the "humanistic-social," "liberal," or "general" parts of the students' education.

2) Engineering education must be more broadly applied, that is, engineers must build bridges between science and the needs of society.

3) Engineers must be made decision makers, since, despite the growing importance of engineering to American life, engineers have not taken a correspondingly important part in the decision-making process.

The recommendations of these studies are similar and recurrent, but the need for change in engineering education remains. Currently, there appears to be a move away from the image of applied science in engineering education.[5] The basis of this apparent change is the growing realization that technological and economic feasibility are not the sole or even the main determinants of what engineers do. Ecological, social, cultural, psychological and political influences are equally important.

The results of the major studies of engineering education tie in closely with the need for developing social-technical competence and interpersonal competence in engineering graduates. Supporting this need, a major study at the University of California, Los Angeles, concluded that every engineering graduate must be capable of communicating with and working with people of other professions to solve the inter-

*See, for example, recent issues of *Engineering Education* (e.g., April 1981) and *Science* (e.g., "Trouble in Science & Engineering Education," by J. Walsh, vol. 200, no. 4470, 1981.)

ENGINEERING EDUCATION December 1981 / 221

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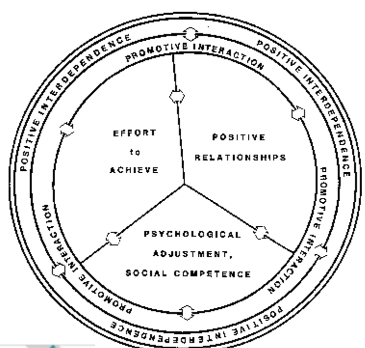
JEE December 1981

Cooperative Learning Research Support

Johnson, D.W., Johnson, R.T., & Smith, K.A. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change*, *30* (4), 26-35.

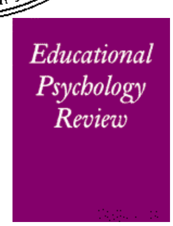
- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes



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

January 2005



March 2007


Pedagogies of Engagement: Classroom-Based Practices

KARL A. SMITH
Department of Civil Engineering
University of Minnesota

SHERI D. SHEPPARD
Department of Mechanical Engineering
Stanford University

DAVID W. JOHNSON
Department of Educational Psychology
University of Minnesota

ROGER T. JOHNSON
Department of Curriculum and Instruction
University of Minnesota

ABSTRACT

Educators, researchers, and policy makers have advocated student involvement for some time as an essential aspect of meaningful learning. In the past twenty years engineering educators have implemented several means of better engaging their undergraduate students, including active and cooperative learning, learning communities, service learning, cooperative education, inquiry and problem-based learning, and team projects. This paper focuses on classroom-based pedagogies of engagement, particularly cooperative and problem-based learning. It includes a brief history, theoretical roots, research support, summary of practices, and suggestions for redesigning engineering classes and programs to include more student engagement. The paper also lays out the research ahead for advancing pedagogies aimed at more fully enhancing students' involvement in their learning.

Keywords: cooperative learning, problem-based learning, student engagement

I. INTRODUCTION TO THE PEDAGOGIES OF ENGAGEMENT

Russ Edgerton introduced the term "pedagogies of engagement" in his 2001 *Education White Paper* [1], in which he reflected on the projects on higher education funded by the Pew Charitable Trusts. He wrote:

"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."

Prior to Edgerton's paper, the widely distributed and influential publication called *The Seven Principles for Good Practice in Undergraduate Education* [2] stressed pedagogies of engagement in concept. Three of the principles speak directly to pedagogies of engagement, namely, that good practice encourages student-faculty contact, cooperation among students, and active learning.

More recently, the project titled The National Survey of Student Engagement (NSSE) [3] deepens our understanding of how students perceive classroom-based learning, in all its forms, as an element in the bigger issue of student engagement in their college education. The NSSE project conceives that student engagement is not just a single course in a student's academic career, but rather a pattern of his or her involvement in a variety of activities. As such, NSSE findings are a valuable assessment tool for colleges and universities to track how successful their academic practices are in engaging their student bodies. The NSSE project is grounded in the proposition that student engagement, the frequency with which students participate in activities that represent effective educational practice, is a meaningful proxy for collegiate quality and, therefore, by extension, quality of education. The annual survey of freshmen and seniors asks students how often they have, for example, participated in projects that required integrating ideas or information from various sources, used e-mail to communicate with an instructor, asked questions in class or contributed to class discussions, received prompt feedback from faculty on their academic performance, participated in community-based projects, or tutored or taught other students. Student responses are organized around five benchmarks:

1. *Level of academic challenge:* Schools encourage achievement by setting high expectations and emphasizing importance of student effort.
2. *Active and collaborative learning:* Students learn more when intensely involved in educational process and are encouraged to apply their knowledge in many situations.
3. *Student-faculty interaction:* Students able to learn from experts and faculty serve as role models and mentors.
4. *Enriching educational experience:* Learning opportunities inside and outside classroom (diversity, technology, collaboration, internships, community service, capstones) enhance learning.
5. *Supportive campus environment:* Students are motivated and satisfied at schools that actively promote learning and stimulate social interaction.

Astin's [4] large-scale correlational study of what matters in college (involving 27,064 students at 309 baccalaureate-granting institutions) found that two environmental factors were by far the most predictive of positive change in college students' academic development, personal development, and satisfaction. These two factors—interaction among students and interaction between faculty and

"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)

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

Pedagogies of Engagement

The American College Teacher:
National Norms for 2007-2008

Methods Used in "All" or "Most"	All – 2005	All – 2008	Assistant - 2008
Cooperative Learning	48	59	66
Group Projects	33	36	61
Grading on a curve	19	17	14
Term/research papers	35	44	47

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

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Undergraduate Teaching Faculty, 2011*

Methods Used in "All" or "Most"	STEM women	STEM men	All other women	All other men
Cooperative learning	60%	41%	72%	53%
Group projects	36%	27%	38%	29%
Grading on a curve	17%	31%	10%	16%
Student inquiry	43%	33%	54%	47%
Extensive lecturing	50%	70%	29%	44%

*Undergraduate Teaching Faculty. National Norms for the 2010-2011 HERI Faculty Survey, www.heri.ucla.edu/index.php

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).

See Smith, et.al, 2005 and Fairweather, 2008, Linking Evidence and Promising Practices in Science, Technology, Engineering, and Mathematics (STEM) Undergraduate Education - http://www7.nationalacademies.org/bose/Fairweather_CommissionedPaper.pdf

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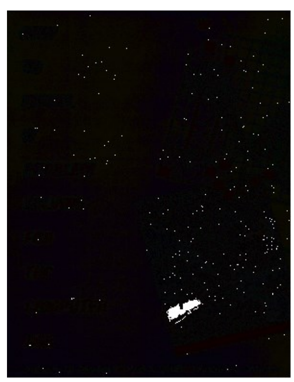
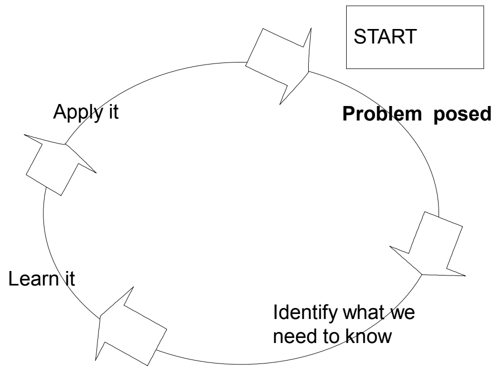
First Course Design Experience UMN – Institute of Technology

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



Problem-Based Learning

Problem-Based Learning



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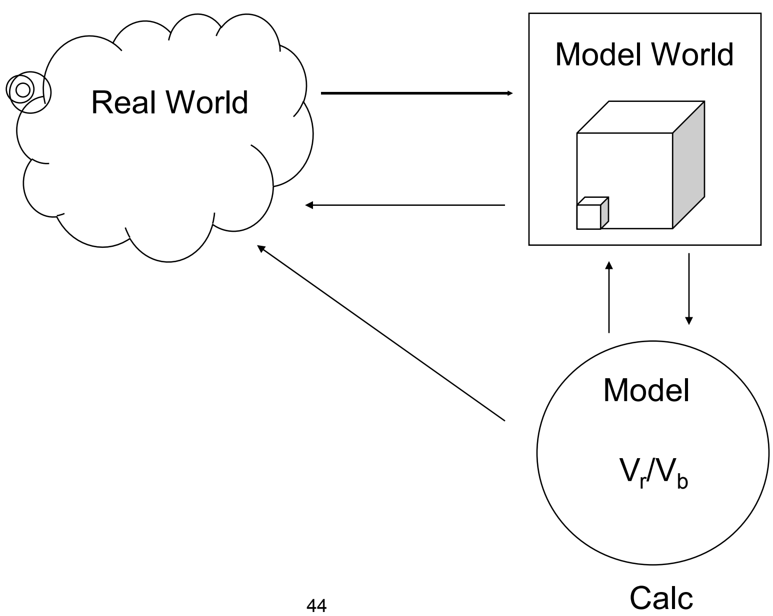

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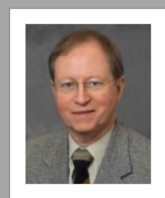
Fundamentals of Engineering Education Research

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

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

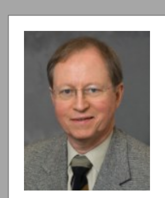


Ruth A.Streveler
Purdue University

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

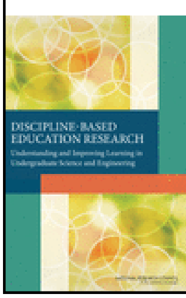
- **Level 0** Teacher
  - Teach as taught
- **Level 1** Effective Teacher
  - Teach using accepted teaching theories and practices
- **Level 2** Scholarly Teacher
  - Assesses performance and makes improvements
- **Level 3** Scholar of Teaching and Learning
  - Engages in educational experimentation, shares results
- **Level 4** Engineering Education Researcher
  - Conducts educational research, publishes archival papers

Source: Streveler, R., Borrego, M. and Smith, K.A. 2007. Moving from the “Scholarship of Teaching and Learning” to “Educational Research:” An Example from Engineering. *Improve the Academy,* Vol. 25, 139-149.

SCIENCE EDUCATION AT THE NATIONAL RESEARCH COUNCIL
www.nationalacademies.org/bose

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.

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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
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- **KARL A. SMITH**, University of Minnesota and Purdue University
- **WILLIAM B. WOOD**, University of Colorado

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*"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

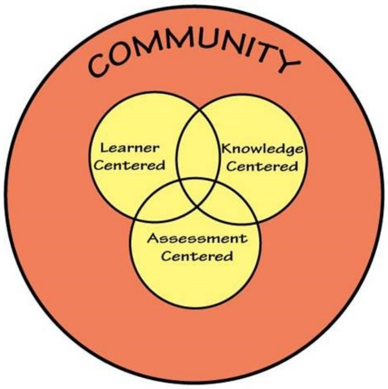
Course Design Foundations

		Science of Instruction (UbD)	
		No	**Yes**
Science of Learning (HPL)	**Yes**	Good Theory/ Poor Practice	Good Theory & Good Practice
	No		Good Practice/ Poor Theory

Bransford, Brown & Cocking. 1999. *How People Learn.* National Academy Press.
Wiggins & McTighe, 2005. *Understanding by Design, 2ed*. ASCD.

How People Learn (HPL)

HPL
Framework



- Expertise implies (Ch. 2):
  - a set of cognitive and metacognitive skills
  - an organized body of knowledge that is deep and contextualized
  - an ability to notice patterns of information in a new situation
  - flexibility in retrieving and applying that knowledge to a new problem

Bransford, Brown & Cocking. 1999. *How people learn.* National Academy Press.

Understanding by Design (UbD)

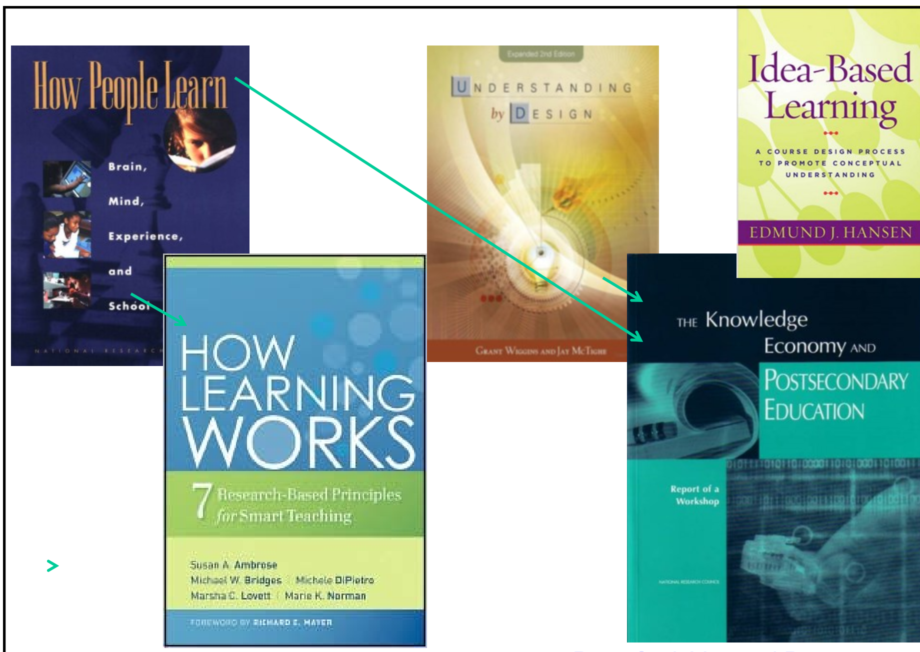
- Stage 1. Identify Desired Results
  - Enduring understanding (enduring outcomes)
  - Important to know and do
  - Worth being familiar with
- Stage 2. Determine Acceptable Evidence
- Stage 3. Plan Learning Experiences and Instruction
- Overall: Are the desired results, assessments, and learning activities ALIGNED?

Wiggins & McTighe, 1997, 2005. *Understanding by Design*. Alexandria, VA: ASCD.

UbD vs. Engineering Design

UbD	Engineering Design
Identify the Desired Results	Determine requirements/ specifications
↓	↓
Determine Acceptable Evidence	Develop or use established metrics to measure against outcomes
↓	↓
Plan Learning Experiences	Plan and develop process, system, etc. to implement

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



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

Revised Bloom's Learning Taxonomy

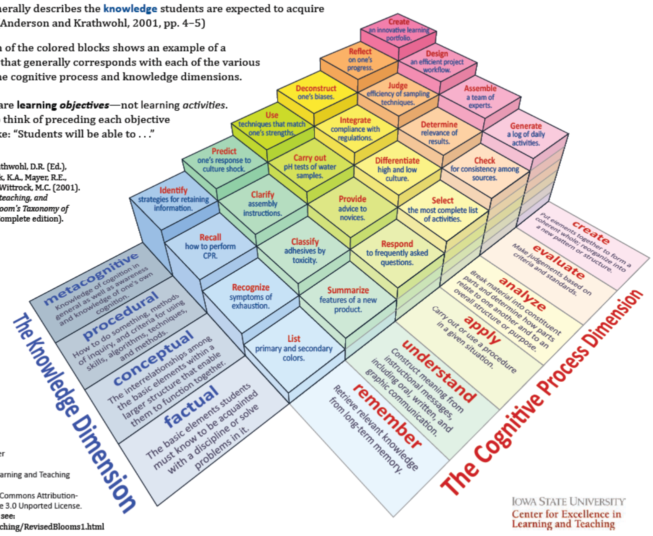
A statement of a **learning objective** contains a verb (an action) and an object (usually a noun).

- The verb generally refers to [actions 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: these are learning ***objectives***—not learning *activities*. It may be useful to think of preceding each objective with something like: "Students will be able to . . ."

*Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Complete edition). New York: Longman.



Model created by: Rex Heer
Iowa State University
Center for Excellence in Learning and Teaching
Updated January, 2012
Licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.
For additional resources, see: www.celt.iastate.edu/teaching/RevisedBlooms1.html

Source: http://www.celt.iastate.edu/pdfs-docs/teaching/RevisedBloomsHandout.pdf

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Interactive Learning Continuum

Make the lecture active	Informal Group Activities	Structured Team Activities	Problems Drive the Course
Active Learning	Collaborative Learning	Formal Cooperative Learning	Problem-Based Learning

Instructor Centered ⟷ **Student Centered**

Strong Evidence Base – Cooperative Learning & Challenge-Based Learning

Prince, M. (2010). NAE FOEE

Informal Cooperative Learning

EDUCATION

Farewell, Lecture?

Eric Mazur

A physics professor describes his evolution from lecturing to dynamically engaging students during class and improving how they learn.

Discussions of education are generally predicated on the assumption that we know what education is. I hope to convince you otherwise by recounting some of my own experiences. When I started teaching introductory physics to undergraduates at Harvard University, I never asked myself how I would educate my students. I did what my teachers had done—I lectured. I thought that was how one learns. Look around anywhere in the world and you'll find lecture halls filled with students and, at the front, an instructor. This approach to education has not changed since before the Renaissance and the birth of scientific inquiry. Early in my career I received the first hints that something was wrong with teaching in this manner, but I had ignored it. Sometimes it's hard to face reality.

When I started teaching, I prepared lecture notes and then taught from them. Because my lectures deviated from the textbook, I provided students with copies of these lecture notes. The infuriating result was that on my end-of-semester evaluations—which were quite good otherwise—a number of students complained that I was "lecturing straight from (his) lecture notes." What was I supposed to do? Develop a set of lecture notes different from the ones I handed out? I decided to ignore the students' complaints.

A few years later, I discovered that the students were right. My lecturing was ineffective, despite the high evaluations. Early on in the physics curriculum—in week 2 of a typical introductory physics course—the Laws of Newton are presented. Every student in such a course can recite Newton's third law of motion, which states that the force of object A on object B in an interaction between two objects is equal in magnitude to the force of B on A—it sometimes is known as "action is reaction." One day, when the course had progressed to more complicated material, I decided to test my students' understanding of this concept not by doing traditional problems, but by asking them a set of basic conceptual questions (1, 2). One of the questions, for example, requires students to compare the forces that a heavy truck and a light car exert on one another when they collide. I expected that the students would have no trouble tackling such questions, but much to my surprise, hardly a minute after the test began, one student asked, "How should I answer these questions? According to what you taught me or according to the way I usually think about these things?" To my dismay, students had great difficulty with the conceptual questions. That was when it began to dawn on me that something was amiss.

In hindsight, the reason for my students' poor performance is simple. The traditional approach to teaching reduces education to a transfer of information. Before the industrial revolution, when books were not yet mass commodities, the lecture method was the only way to transfer information from one generation to the next. However, education is so

Click here. Students continually discuss concepts among themselves and with the instructor during class. Discussions are spurred by multiple-choice conceptual questions that students answer using a clicker device. See supporting online text for examples of such "clicker questions."

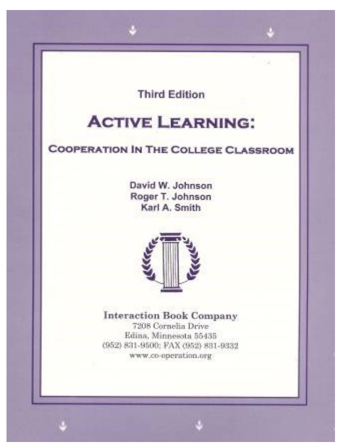
Department of Physics, Harvard University, Cambridge, MA 02138, USA. E-mail: mazur@physics.harvard.edu

January 2, 2009—Science, Vol. 323 – www.sciencemag.org

Calls for evidence-based instruction practices

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)

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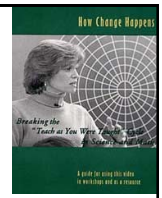
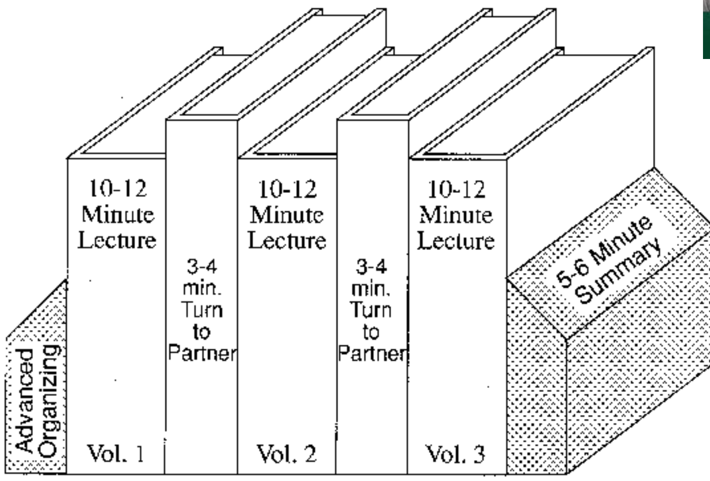
Book Ends on a Class Session





Smith, K.A. 2000. Going deeper: Formal small-group learning in large classes. Energizing large classes: From small groups to learning communities. *New Directions for Teaching and Learning*, 2000, 81, 25-46. [NDTL81Ch3GoingDeeper.pdf]

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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?

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

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

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

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

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

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

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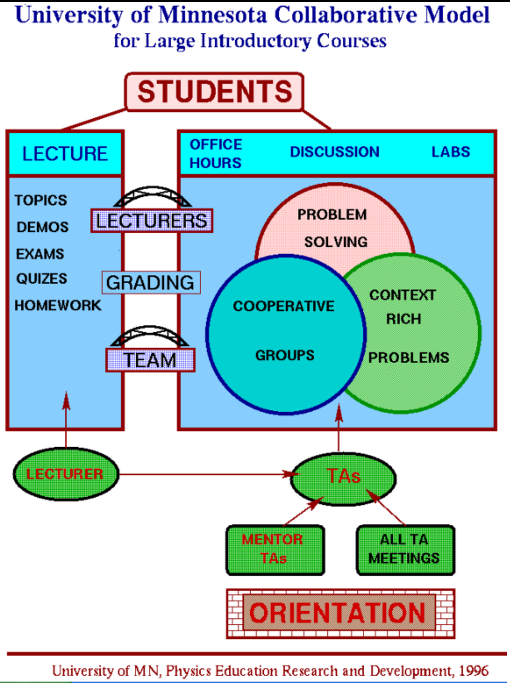
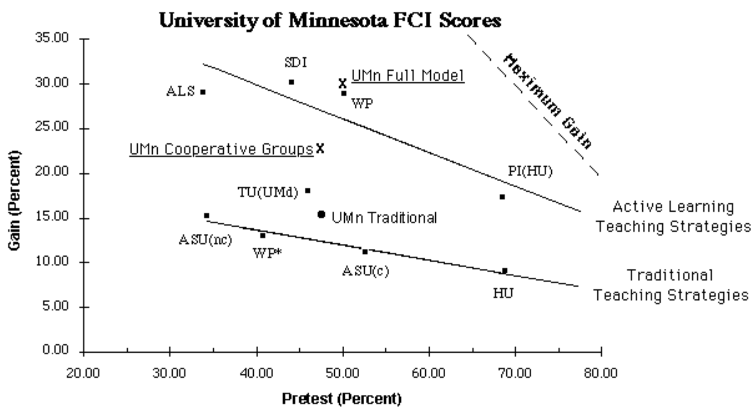


http://groups.physics.umn.edu/physed/Research/MNModel/Model.html

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.

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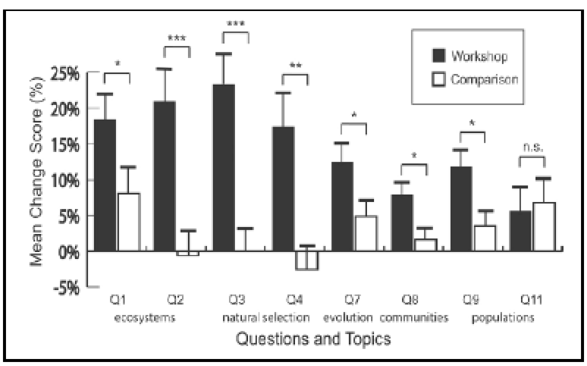
Workshop Biology

Traditional passive lecture vs. "Workshop biology"



Source: Udovic et al. 2002

Biology

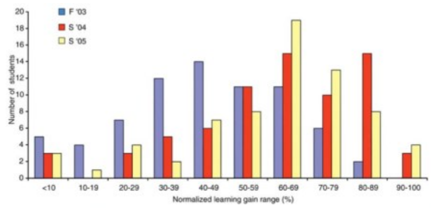


Figure 3. Comparison of normalized learning gains (% of possible maximum) in 10% increments on 12 common pretest and posttest questions for students in one traditional (F'03) and two interactive (S'04, S'05) classes. Normalized learning gains were computed as in Figure 2.

Table 4. Comparison of average performance on different assessments for all three courses

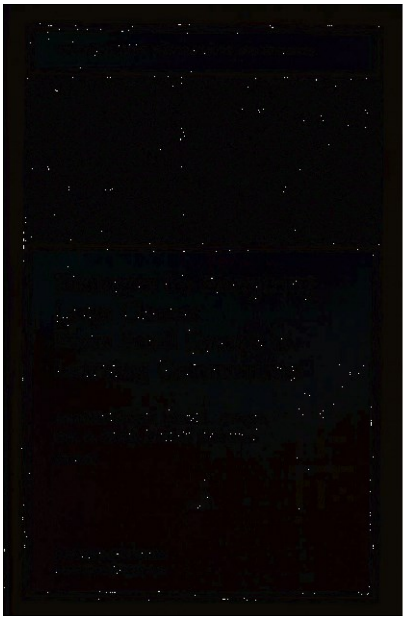
Assessment	or maximum score)		
	F'03	S'04	S'05
Pretest (12 questions)[a]	34	31	37
posttest (12 questions)[a]	65	74	72
Raw learning gain	31	43	38
Normalized learning gain[b]	46	62	61
Hourly exams	71	71	73
Final exam	77	71	76
Problem sets	82	85	90
Participation	N/A	86	86
Final total points	76	81	81

[a]Data based only on the 12 questions that were common to all three pretests and posttests (see Appendix A).
[b]Average for each class is shown. Normalized learning gains were computed as described in the text and the legend to Figure 2.

Source: Knight, J. and Wood, W. (2005). Teaching more by lecturing less. *Cell Biol Educ*. 4(4): 298–310.

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

Informal Cooperative Learning Planning Form

Description of the Lecture

1. **Lecture Topic:** ____________________
2. **Objectives** (Major Understandings Students Need To Have At The End Of The Lecture):
   a. ____________________
   b. ____________________
3. **Time Needed:** ____________________
4. **Method For Assigning Students To Pairs Or Triads:** __________
5. **Method Of Changing Partners Quickly:** ____________________
6. **Materials** (such as transparencies listing the questions to be discussed and describing the **formulate, share, listen, create** procedure):
   ____

Advanced Organizer Question(s)

Questions should be aimed at promoting **advance organizing** of what the students know about the topic to be presented and **establishing expectations** as to what the lecture will cover.

1. ____________________
2. ____________________
3. ____________________

Cognitive Rehearsal Questions

List the specific questions to be asked every 10 or 15 minutes to ensure that participants understand and process the information being presented. Instruct students to use the **formulate, share, listen, and create** procedure.

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Monitor by systematically observing each pair. Intervene when it is necessary. Collect data for whole class processing. Students' explanations to each other provide a window into their minds that allows you to see what they do and do not understand. Monitoring also provides an opportunity for you to get to know your students better.

Summary Question(s)

Give an ending discussion task and require students to come to consensus, write down the pair or triad's answer(s), sign the paper, and hand it in. Signatures indicate that students agree with the answer, can explain it, and guarantee that their partner(s) can explain it. The questions could (a) ask for a summary, elaboration, or extension of the material presented or (b) precue the next class session.

1. ____________________
2. ____________________

Celebrate Students' Hard Work

1. ____________________
2. ____________________

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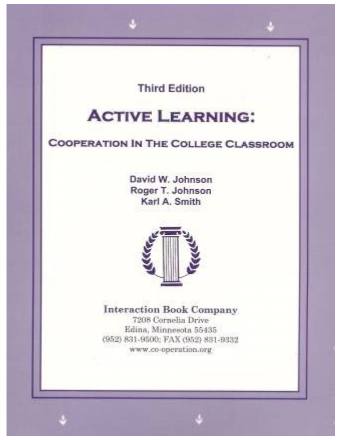
Active Learning: Cooperation in the College Classroom

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



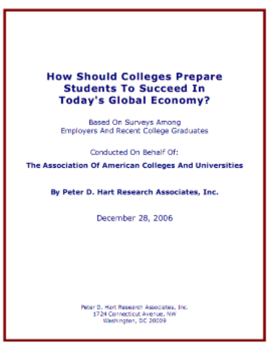
See Cooperative Learning Handout (CL College-912.doc) 73

Formal Cooperative Learning Task Groups

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
(Shuman, L., Besterfield-Sacre, M., and McGourty, J., "The ABET Professional Skills-Can They Be Taught? Can They Be Assessed?" Journal of Engineering Education, Vo. 94, No. 1, 2005, pp. 41–55.)


How Should Colleges Prepare Students To Succeed In Today's Global Economy?

Based On Surveys Among Employers And Recent College Graduates

Conducted On Behalf Of:
The Association Of American Colleges And Universities

By Peter D. Hart Research Associates, Inc.

December 28, 2006

http://www.aacu.org/advocacy/leap/documents/Re8097abcombined.pdf

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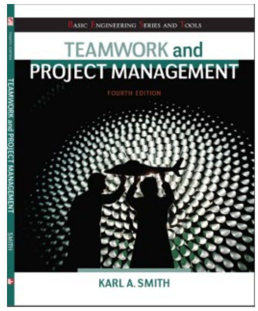
Top Three Main Engineering Work Activities

Engineering Total

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

Civil/Architectural

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



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

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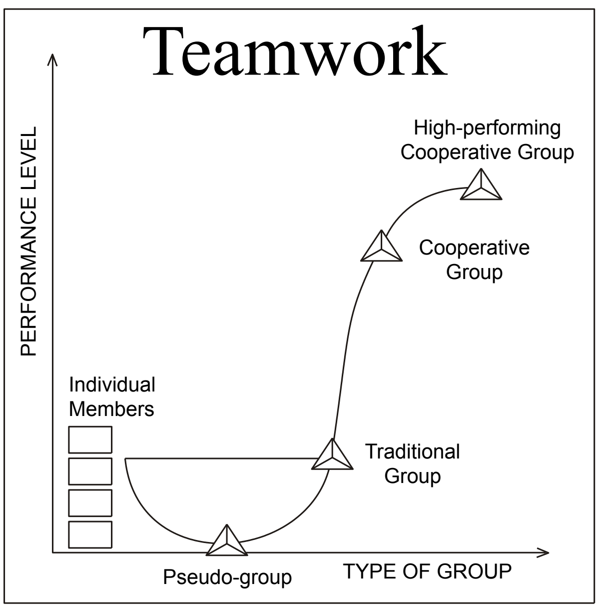
www.mhhe.com/smithteamwork4e



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Characteristics of Effective Teams?

- ?
- ?

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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).

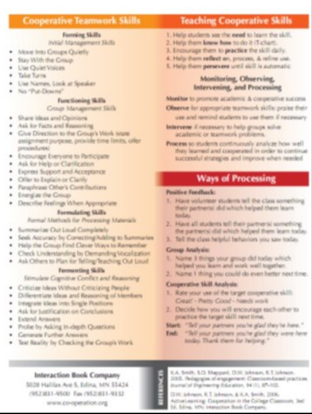
Key Concepts

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

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

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

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Decisions,Decisions

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

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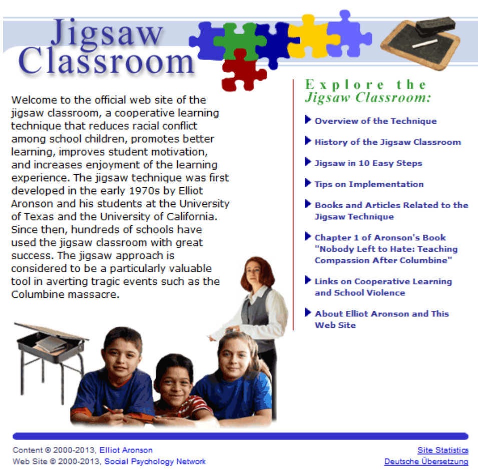
Formal Cooperative Learning – Types of Tasks

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/

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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

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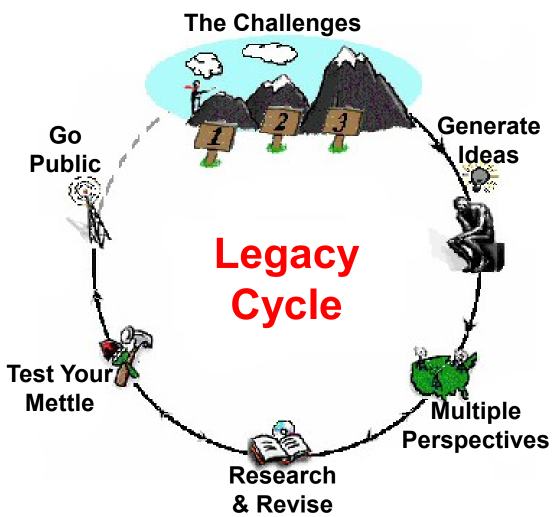
Challenge-Based Instruction with the Legacy Cycle



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

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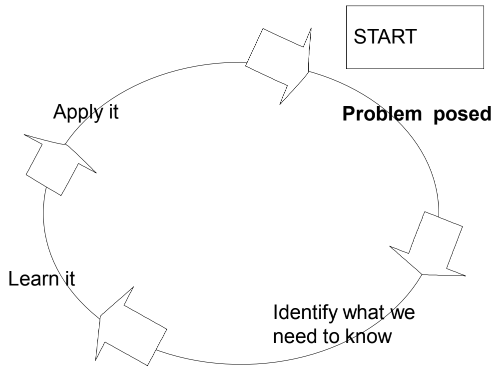
Problem-Based Learning



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Problem-Based Cooperative Learning

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

Jodi Hilton for The New York Times

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

By SARA RIMER
Published: January 12, 2009

COMMENTS (00)
E-MAIL
PRINT
SINGLE PAGE

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

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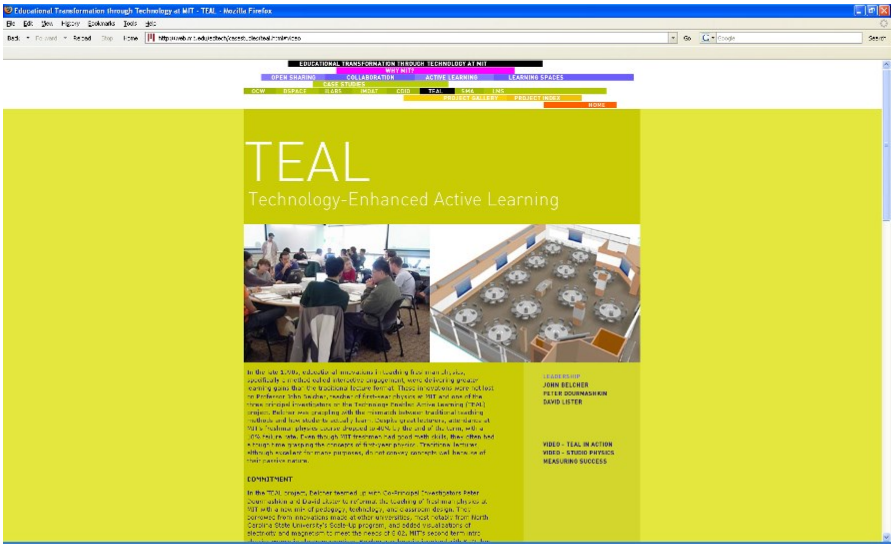
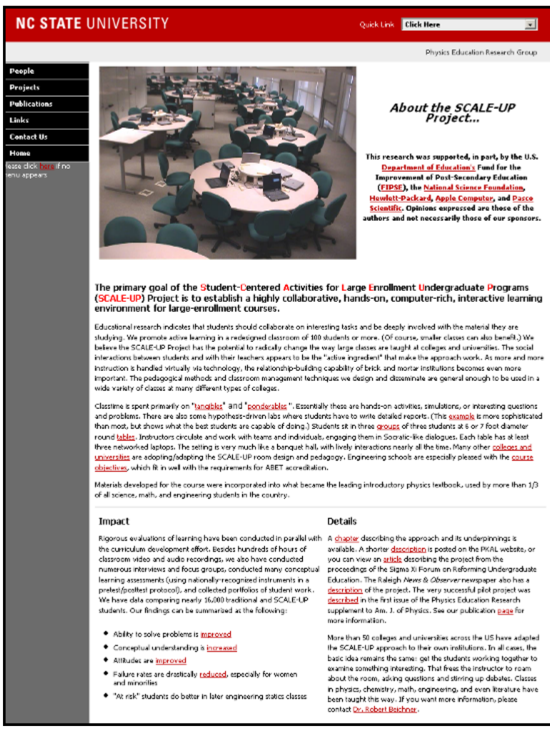
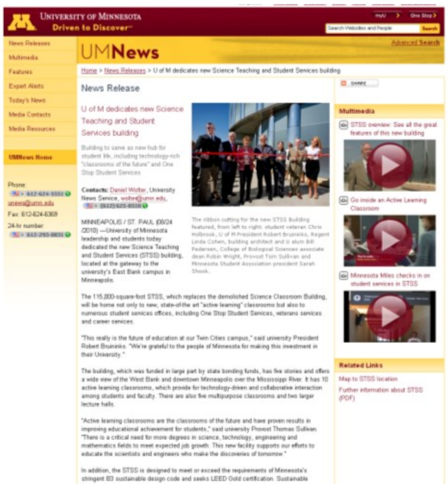
January 13, 2009—New York Times – http://www.nytimes.com/2009/01/13/us/13physics.html?em



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



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


UNIVERSITY OF MINNESOTA
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UMNews
Home > News Releases > U of M dedicates new Science Teaching and Student Services building

News Release

U of M dedicates new Science Teaching and Student Services building

Building to serve as new hub for student life, including technology-rich "classrooms of the future" and One Stop Student Services

Contacts: Daniel Wolter, University News Service, wolter@umn.edu,

MINNEAPOLIS / ST. PAUL (08/24/2010) —University of Minnesota leadership and students today dedicated the new Science Teaching and Student Services (STSS) building, located at the gateway to the university's East Bank campus in Minneapolis.

The ribbon cutting for the new STSS Building featured, from left to right: student veteran Chris Holbrook, U of M President Robert Bruininks, Regent Linda Cohen, building architect and U alum Bill Pedersen, College of Biological Sciences associate dean Robin Wright, Provost Tom Sullivan and Minnesota Student Association president Sarah Shook.

The 115,000-square-foot STSS, which replaces the demolished Science Classroom Building, will be home not only to new, state-of-the art "active learning" classrooms but also to numerous student services offices, including One Stop Student Services, veterans services and career services.

"This really is the future of education at our Twin Cities campus," said university President Robert Bruininks. "We're grateful to the people of Minnesota for making this investment in their University."

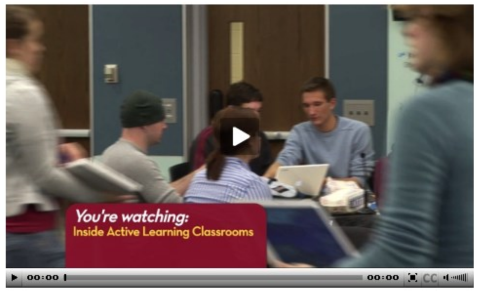
The building, which was funded in large part by state bonding funds, has five stories and offers a wide view of the West Bank and downtown Minneapolis over the Mississippi River. It has 10 active learning classrooms, which provide for technology-driven and collaborative interaction among students and faculty. There are also five multipurpose classrooms and two larger lecture halls.

"Active learning classrooms are the classrooms of the future and have proven results in improving educational achievement for students," said university Provost Thomas Sullivan. "There is a critical need for more degrees in science, technology, engineering and mathematics fields to meet expected job growth. This new facility supports our efforts to educate the scientists and engineers who make the discoveries of tomorrow."

In addition, the STSS is designed to meet or exceed the requirements of Minnesota's stringent B3 sustainable design code and seeks LEED Gold certification. Sustainable

Multimedia
STSS overview: See all the great features of this new building
Go inside an Active Learning Classroom
Minnesota Miles checks in on student services in STSS

Related Links
Map to STSS location
Further information about STSS (PDF)



http://mediamill.cla.umn.edu/mediamill/embed/78755

http://www1.umn.edu/news/news-releases/2010/UR_CONTENT_248261.html

http://www.youtube.com/watch?v=IfT_hoiuY8w

http://youtu.be/lfT_hoiuY8w

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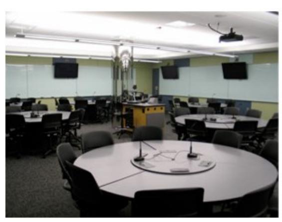
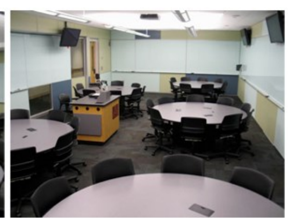
Inside an Active Learning Classroom

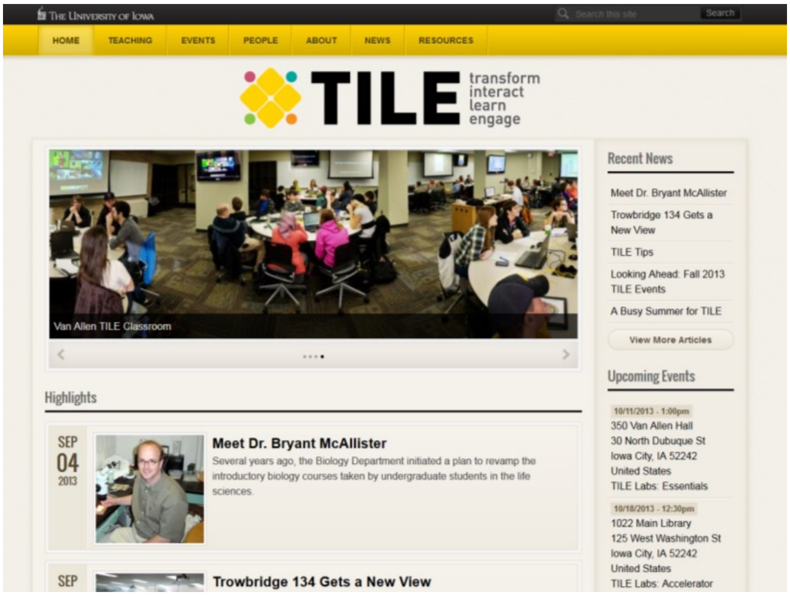
- STSS at the University of Minnesota

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/

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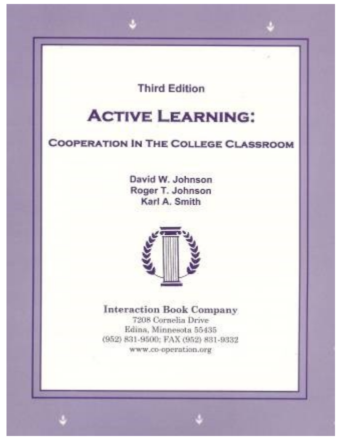
http://www.udel.edu/inst/

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)

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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

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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

Psychological Safety	LOW	HIGH
HIGH	**Comfort zone** 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.	**Learning zone** Here the focus is on collaboration and learning in the service of high-performance outcomes. The hospitals described in this article fall into this quadrant.
LOW	**Apathy zone** 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.	**Anxiety zone** 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.

Edmonson-Competitive_Advantage_of_Learning-HBR-2008.pdf

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Edmonson-Competitive_Advantage_of_Learning-HBR-2008.pdf

Designing and Implementing Cooperative Learning

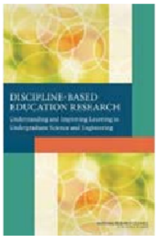
- Think like a designer
- Ground practice in robust theoretical framework
- Start small, start early and iterate
- Celebrate the successes; problem-solve the failures

Global Calls for Reform

K-12 Engineering

Research-based Transformation

Discipline-Based Education Research (DBER)

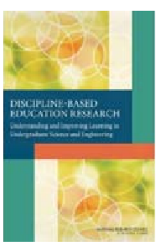


National Research Council
2012

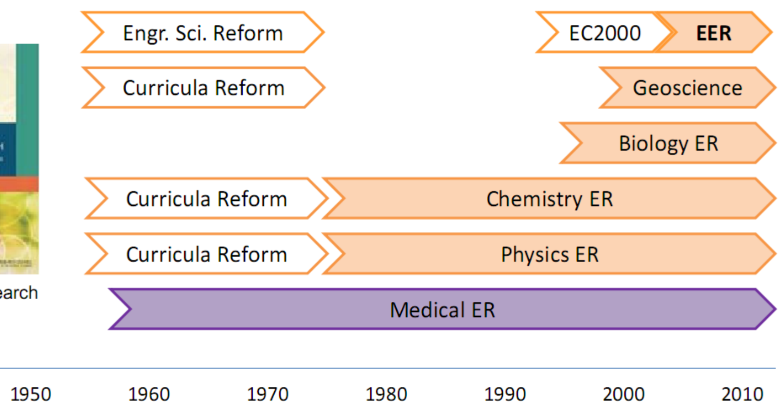
- Discipline-based education research (DBER) is a **small but growing field of inquiry**.
- **Conducting DBER** and **using DBER** findings are **distinct but interdependent** pursuits.
- DBER is **inherently interdisciplinary.**
- Individual fields of DBER have made **notable inroads** in terms of establishing 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**.

PURDUE ENGINEERING EDUCATION

Discipline-Based Education Research Timeline



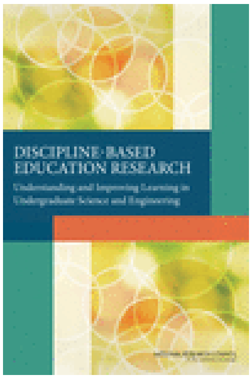
National Research Council
2012



PURDUE ENGINEERING EDUCATION

DBER is **located** in the relevant disciplinary school, e.g. medicine, physics.

Discipline-Based Education Research (DBER) Report Update



Discipline-Based Education Research

Practitioner Guide

In Preparation
Coming 2014

ASEE *Prism Summer 2013*

National Research Council
Summer 2012 – http://www.nap.edu/catalog.php?record_id=13362

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 Academic and Teamwork Skills Objectives: Every lesson has both (a) academic and (b) interpersonal and small group (teamwork) skills objectives.

Decide on Group Size: Learning groups should be small (groups of two or three members, four at the most).

Decide on Group Composition (Assign Students to Groups): Assign students to groups randomly or select groups yourself. Usually you will wish to maximize the heterogeneity in each group.

Assign Roles: Structure student-student interaction by assigning roles such as Reader, Recorder, Encourager of Participation and Checker for Understanding.

Arrange the Room: Group members should be "knee to knee and eye to eye" but arranged so they all can see the instructor at the front of the room.

Plan Materials: Arrange materials to give a "sink or swim together" message. Give only one paper to the group or give each member part of the material to be learned.

Explain Task And Cooperative Structure

Explain the Academic Task: Explain the task, the objectives of the lesson, the concepts and principles students need to know to complete the assignment and the procedures they are to follow.

Explain the Criteria for Success: Student work should be evaluated on a criteria-referenced basis. Make clear your criteria for evaluating students' work.

***Structure Positive Interdependence**: Students must believe they "sink or swim together." Always establish mutual goals (students are responsible for their own learning and the learning of all other group members). Supplement, goal interdependence with celebration/reward, resource, role, and identity interdependence.

Structure Intergroup Cooperation: Have groups check with and help other groups. Extend the benefits of cooperation to the whole class.

***Structure Individual Accountability**: Each student must feel responsible for doing his or her share of the work and helping the other group members. Ways to ensure accountability are frequent oral quizzes of group members picked at random, individual tests, and assigning a member the role of Checker for Understanding.

***Specify Expected Behaviors**: The more specific you are about the behaviors you want to see in the groups, the more likely students will do them. Social skills may be classified as **forming** (staying with the group, using quiet voices), **functioning** (contributing, encouraging others to participate), **formulating** (summarizing, elaborating), and **fermenting** (criticizing ideas, asking for justification). Regularly teach the interpersonal and small group skills you wish to see used in the learning groups.

Monitor and Intervene

***Arrange Face-to-Face Promotive Interaction**: Conduct the lesson in ways that ensure that students promote each other's success face-to-face.

Monitor Students' Behavior: This is the fun part! While students are working, you circulate to see whether they understand the assignment and the material, give immediate feedback and reinforcement, and praise good use of group skills. Collect observation data on each group and student.

Intervene to Improve Taskwork and Teamwork: Provide **taskwork assistance** (clarify, reteach) if students do not understand the assignment. Provide **teamwork assistance** if students are having difficulties in working together productively.

Evaluate and Process

Evaluate Student Learning: Assess and evaluate the quality and quantity of student learning. Involve students in the assessment process.

***Process Group Functioning**: Ensure each student receives feedback, analyzes the data on group functioning, sets an improvement goal, and participates in a team celebration. Have groups routinely list three things they did well in working together an done thing they will do better tomorrow. Summarize as a whole class. Have groups celebrate their success and hard work.

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Cooperative Lesson Planning Form

Subject Area: ______ Date: ______

Lesson: ______

Objectives

Academic: ______

Social Skills: ______

Preinstructional Decisions

Group Size: ______ Method Of Assigning Students: ______

Roles: ______

Room Arrangement: ______

Materials: ______

- ◊ One Copy Per Group
- ◊ One Copy Per Person
- ◊ Jigsaw
- ◊ Tournament
- ◊ Other: ______

Explain Task And Cooperative Goal Structure

1. Task: ______
2. Criteria For Success: ______
3. Positive Interdependence: ______
4. Individual Accountability: ______
5. Intergroup Cooperation: ______
6. Expected Behaviors: ______

Monitoring And Intervening

1. Observation Procedure: ______ Formal ______ Informal
2. Observation By: ______ Teacher ______ Students ______ Visitors
3. Intervening For Task Assistance: ______
4. Intervening For Teamwork Assistance: ______
5. Other: ______

Evaluating And Processing

1. Assessment Of Members' Individual Learning: ______
2. Assessment Of Group Productivity: ______
3. Small Group Processing: ______
4. Whole Class Processing: ______
5. Charts And Graphs Used: ______
6. Positive Feedback To Each Student: ______
7. Goal Setting For Improvement: ______
8. Celebration: ______
9. Other: ______

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Resources

- Design Framework – How People Learn (HPL) & Understanding by Design (UdB) Process
  - Ambrose, S., et.al. 2010. *How learning works: 7 research based principles for smart* teaching. Jossey-Bass
  - Bransford, John, Vye, Nancy, and Bateman, Helen. 2002. Creating High-Quality Learning Environments: Guidelines from Research on How People Learn. *The Knowledge Economy and Postsecondary Education: Report of a Workshop*. National Research Council. Committee on the Impact of the Changing Economy of the Education System. P.A. Graham and N.G. Stacey (Eds.). Center for Education. Washington, DC: National Academy Press. http://www.nap.edu/openbook/0309082927/html/
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  - Streveler, R.A., Smith, K.A. and Pilotte, M. 2012. Content, Assessment and Pedagogy (CAP): An Integrated Engineering Design Approach. In Dr. Khairiyah Mohd Yusof, Dr. Shahrin Mohammad, Dr. Naziha Ahmad Azli, Dr. Mohamed Noor Hassan, Dr. Azlina Kosnin and Dr. Sharifah Kamilah Syed Yusof (Eds.). *Outcome-Based Education and Engineering Curriculum: Evaluation, Assessment and Accreditation*, Universiti Teknologi Malaysia, Malaysia [Streveler-Smith-Pilotte_OBE_Chapter-CAP-v11.pdf]
  - Wiggins, G. & McTighe, J. 2005. *Understanding by Design: Expanded Second Edition*. Prentice Hall.
- Content Resources
  - Donald, Janet. 2002. Learning to think: Disciplinary perspectives. San Francisco: Jossey-Bass.
  - Middendorf, Joan and Pace, David. 2004. Decoding the Disciplines: A Model for Helping Students Learn Disciplinary Ways of Thinking. New Directions for Teaching and Learning, 98.
- Cooperative Learning
  - Cooperative Learning (Johnson, Johnson & Smith) - Smith web site – www.ce.umn.edu/~smith
  - Smith (2010) Social nature of learning: From small groups to learning communities. New Directions for Teaching and Learning, 2010, 123, 11-22 [NDTL-123-2-Smith-Social_Basis_of_Learning-.pdf]
  - Smith, Sheppard, Johnson & Johnson (2005) Pedagogies of Engagement [Smith-Pedagogies_of_Engagement.pdf]
  - Johnson, Johnson & Smith. 1998. Cooperative learning returns to college: What evidence is there that it works? Change, 1998, 30 (4), 26-35. [CLReturnstoCollege.pdf]
- Other Resources
  - University of Delaware PBL web site – www.udel.edu/pbl
  - PKAL – Pedagogies of Engagement – http://www.pkal.org/activities/PedagogiesOfEngagementSummit.cfm
  - Fairweather (2008) Linking Evidence and Promising Practices in Science, Technology, Engineering, and Mathematics (STEM) Undergraduate Education - http://www7.nationalacademies.org/bose/Fairweather_CommissionedPaper.pdf

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