ASEE Main Plenary, 8:45 a.m. – 10:15 a.m.
Vancouver International Conference Centre, West Ballroom CD
Expected to draw over 2,000 attendees, this year's plenary features Karl A. Smith, Cooperative Learning Professor of Engineering Education at Purdue University and Morse–Alumni Distinguished Teaching Professor & Professor of Civil Engineering at the University of Minnesota.
Smith has been at the University of Minnesota since 1972 and has been active in ASEE since he became a member in 1973. For the past five years, he has been helping start the engineering education Ph.D. program at Purdue University. He is a Fellow of the American Society for Engineering Education and past Chair of the Educational Research and Methods Division. He has worked with thousands of faculty all over the world on pedagogies of engagement, especially cooperative learning, problem-based learning, and constructive controversy.
On the occasion of the 100th anniversary of the Journal of Engineering Education and the release of ASEE's Phase II report *Creating a Culture for Scholarly and Systematic Innovation in Engineering Education* (Jamieson/Lohmann report), the plenary will celebrate these milestones and demonstrate rich, mutual interdependences between practice and inquiry into teaching and learning in engineering education. Depth and range of the plenary will energize the audience and reflects expertise and interests of conference participants. One of ASEE's premier educators and researchers, Smith will draw upon our roots in scholarship to set the stage and weave the transitions for six highlighted topics selected for their broad appeal across established, evolving, and emerging practices in engineering education.

Highlights from Monday:

Monday's **Main Plenary** by Karl A. Smith, Cooperative Learning Professor of Engineering Education at Purdue University and Morse–Alumni Distinguished Teaching Professor & Professor of Civil Engineering at the University of Minnesota, focused on six highlighted topics (presented by six different educators) selected for their broad appeal across established, evolving, and emerging practices in engineering education.

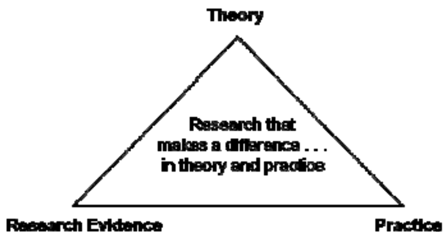
Celebration of Two Major ASEE Milestones

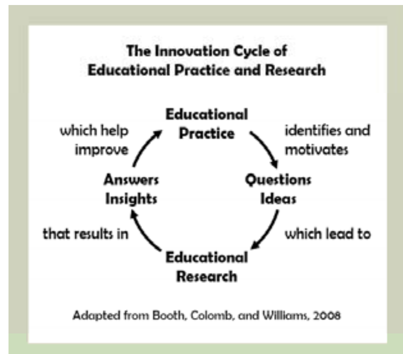

Creating a Culture for Scholarly and Systematic Innovation in Engineering Education
Ensuring U.S. engineering has the right people with the right talent for a global society

2009 ASEE Annual Conference and Exposition
Austin, Texas • Tuesday, June 16, 2009

2011 ASEE Annual Conference and Exposition
Vancouver, British Columbia • Monday, June 27, 2011

One BIG Idea; Two Perspectives

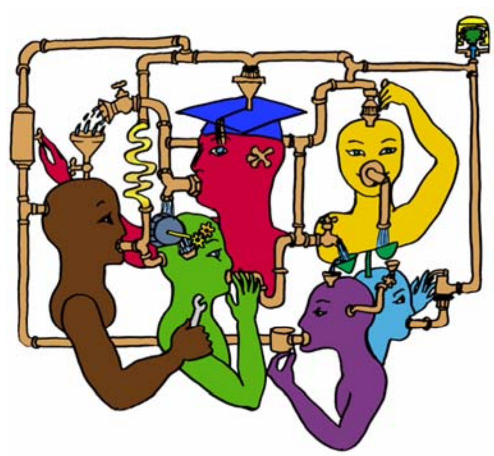




Jamieson & Lohmann (2009)

Engineering Education Innovation

Karl Smith's Innovation Story: Cooperative Learning



Illustrations by Lila M. Smith, ca. 1975

Agenda

- Introduction, Purpose, and Overview
  - **Karl Smith**, Purdue University/ University of Minnesota

- Active/Cooperative Learning
  - **Michael Prince**, Bucknell University
- Service/Problem-based Learning
  - **Khairiyah Mohd Yusof**, Universiti Teknologi Malaysia
- Reflection (~ 1 minute)

- First-year Engineering Design Courses
  - **Jacquelyn Sullivan**, University of Colorado, Boulder
- Interdisciplinary Capstone Courses
  - **Arnold Pears**, Uppsala University
- Reflection (~1 minute)

- Assessment of Conceptual Understanding
  - **David Darmofal**, MIT
- Systematic Formative Assessment
  - **Anna Dollár**, Miami University
- Reflection (~1 minute)

- Close – Follow Up Sessions
  - Monday, 6 PM, Engineering Education Research Community
  - Wednesday, 10:30 AM, – Jamieson/Lohmann Report

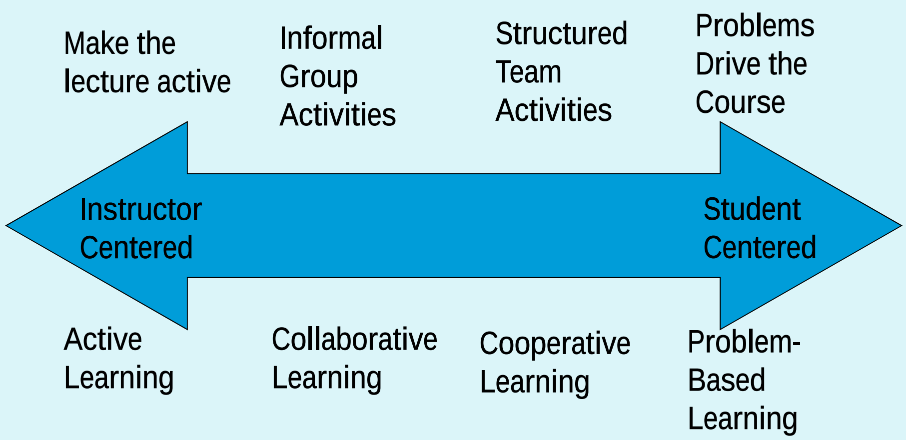
Active/Cooperative Learning

Michael Prince

Professor of Chemical Engineering

Bucknell University

The Active Learning Continuum

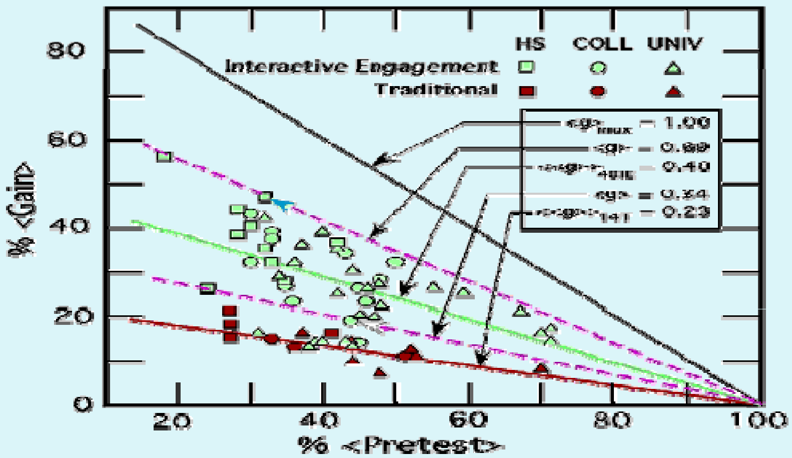


Effectiveness of Short Activities: Less Can Be More

	With Pause	Without Pause
Short term recall	108 correct facts recalled after lecture	80 correct facts recalled after lecture
Long term recall	Average exam score = 84.9	Average exam score = 76.7

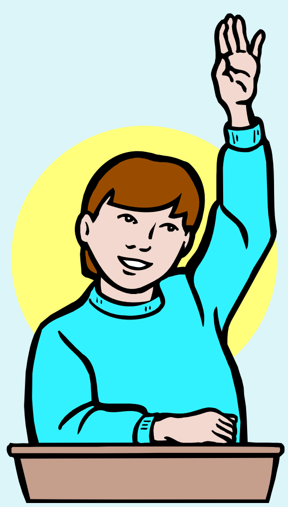
Ruhl et al., Using the Pause Procedure to Enhance Lecture Recall", Teacher Education and Special Education, Vol. 10, Winter 1987

Active Learning:
Twice As Effective as Lecturing



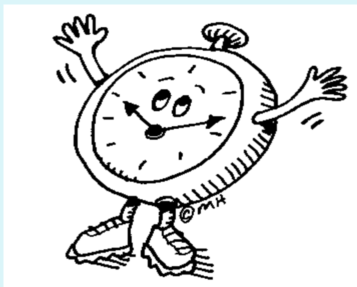
Hake, R., “Interactive Engagement vs. Traditional Methods”, Am. J. of Physics, 1998.

Incorporating Active Learning:
Variations on How We Ask Questions



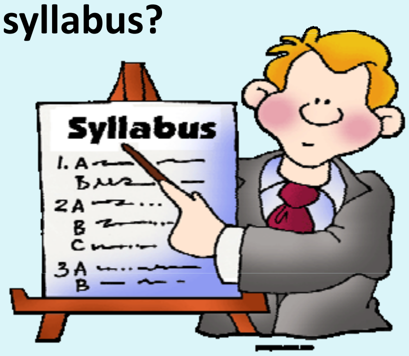
Common Faculty Questions

How much time does it take to prepare?



Often very little

Can I still cover the syllabus?



YES!!

Active Learning and Teams

Consider the Following Scenario

- You assign 4 homework problems to teams of 4 students
- Students pick teams
- One solution handed in
- Same grade for all

What could go wrong?

CL Criteria:
Structures to Improve Teams

Regular self-assessment of group functioning

Face-to-face interaction

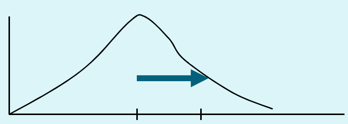
Appropriate use of interpersonal skills

Positive interdependence

Individual accountability

Does Cooperative Learning Work?

- <u>Achievement</u>:



- <u>Retention:</u>

- <u>Student Attitudes</u>

Springer et al., “Effects of small-group learning on undergraduates in science , mathematics, engineering, and technology: A meta-analysis”. Review of Educational Research, 1999

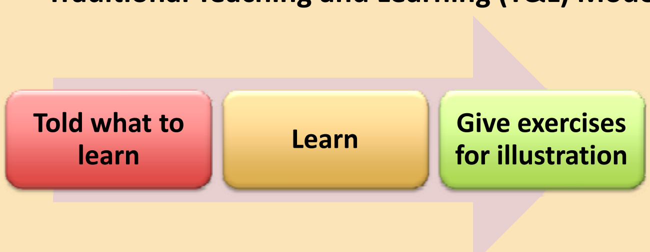
UTM

PROBLEM-BASED LEARNING (PBL)

Khairiyah Mohd Yusof, PhD
Director,
Regional Centre for Engineering Education (RCEE)
Universiti Teknologi Malaysia (UTM)

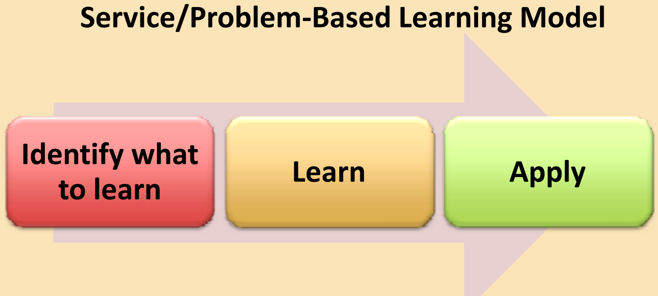
UTM

Traditional Teaching and Learning (T&L) Model



Deductive T&L

Service/Problem-Based Learning Model



Inductive T&L

INSPIRING CREATIVE & INNOVATIVE MINDS

UTM

Critical Elements in Problem-Based Learning (PBL)

Realistic Problem

Instructors as Designer & Coach / Facilitator

Student as Problem Solver

O. S. Tan (2003)

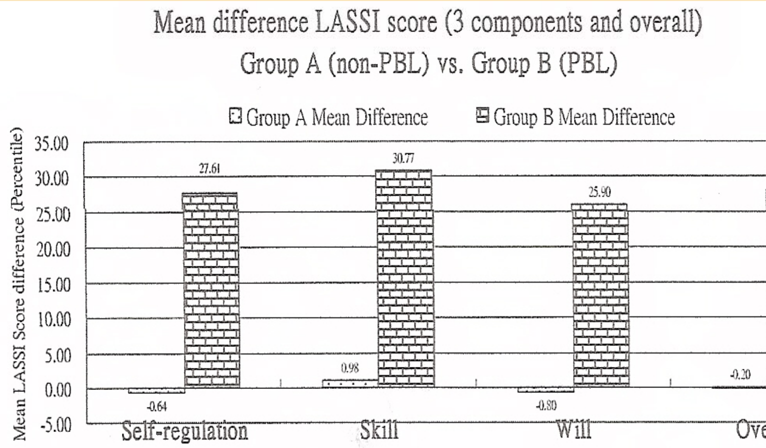
UTM

Why PBL? Effective outcomes based on research

- Knowledge retention
- Skills
- Positive attitude
- Deep learning
- Meta-cognitive skills

Strobel & Barneveld, 2009
Prince & Felder, 2006
Woods et al, 2000

Why PBL?
- a sample research finding



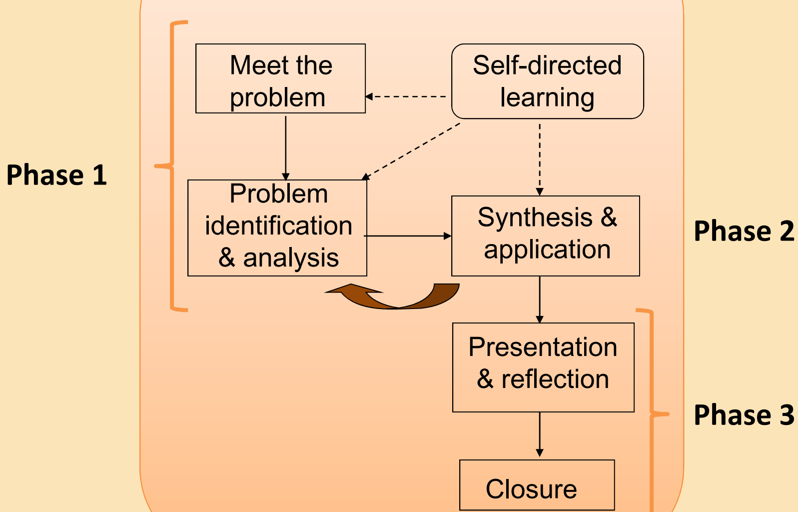
Learning
And
Studying
Strategy
Inventory

Downing 2007, 2010

p < 0.01 for all components

INSPIRING **CREATIVE & INNOVATIVE** MINDS

The PBL Process



INSPIRING **CREATIVE & INNOVATIVE** MINDS

www.utm.my

PBL in a Typical Engineering Course…

Coping with change – need to explain and rationalize => MOTIVATE!!

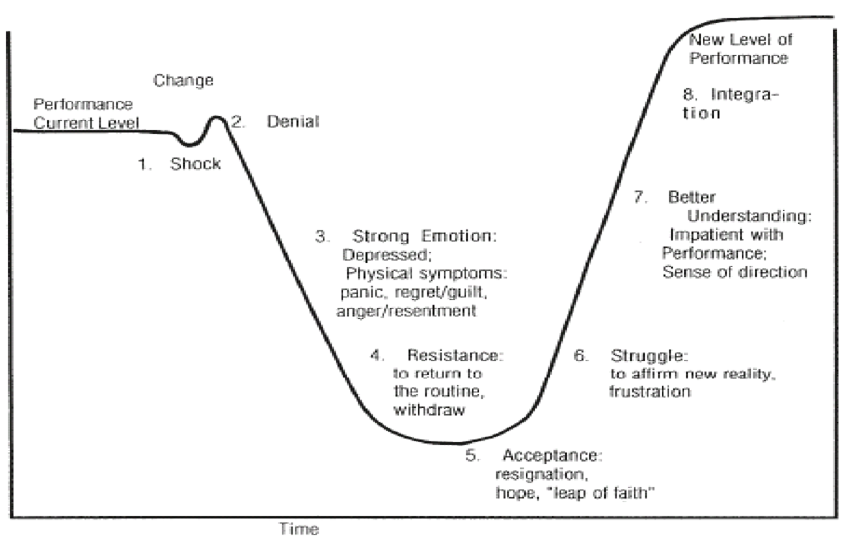
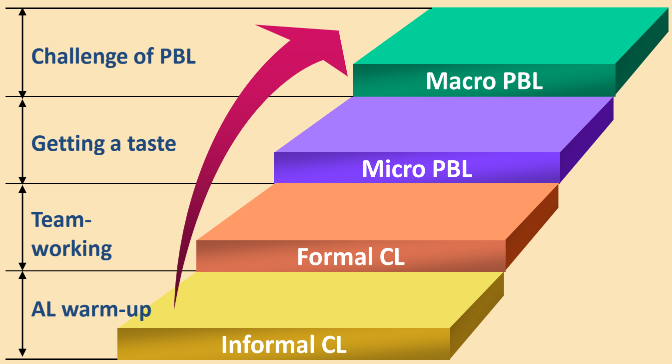


Figure 1-1 The *grieving* process as a model of how we cope with change

Woods, 1994

Gradual move towards PBL…

If unfamiliar with active learning techniques, start gradually



Go for training & read – embrace lifelong learning!

INSPIRING CREATIVE & INNOVATIVE MINDS

Reflection

- Take a moment to think about the ideas, strategies, evidence and experiences presented
- Identify practices that resonate
- Start thinking about follow up

First Year Engineering Design

Jacquelyn Sullivan

Associate Dean
College of Engineering and Applied Science
University of Colorado Boulder

jacquelyn.sullivan@colorado.edu

Design Education

Engineering Design

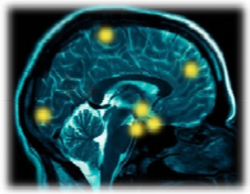
- What engineers do…
- Design within constraints
- Systematic
- Thoughtful
- People centered

- Focused on students
- Knowledge and professional practice
- Social activity… with people, for people
- Ambiguity

See work of Dym, Sheppard

Evolution of First Year Design

- Early –mid 1990's
- The leap: science & math → engineering
- Acquire facts; organize knowledge
- Connect to existing knowledge
- Multidisciplinary
- *Synthesis*
- Hopeful outcomes



See work of Froyd and Ohland

Start Early: First Year Design

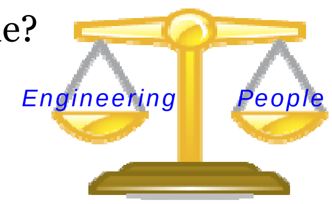
- Not so common…
- ASEE and CASEE benchmarking

  9% (10/113) – generalize to ~35 nationally?
- Early design → reflection → success
- Self efficacy research enticing for First Year Design
  - Engineering experiences shape confidence
  - Importance of *mastery* experiences

See survey summary by Brannan,
research by Stevens and Hutchinson-Green

Learning Happens Between People

- Technical vs social
- Engineering is about people
- Neglectful relationship to people?
- Socio-technical work
- Implications of outsourcing the First Year
- First Year Design



See research of Stevens

Engaging

- Learning requires feedback
- Solving a problem →connections
- Entwinement
  - Learning and engaging
  - Mind and heart
  - Social and technical
- *Context* for engineering design challenges…
  - Gender differences in patterns of intellectual development
  - Is to *engineer in context* particularly important for women?
- Design!

See research of Adams, Kilgore

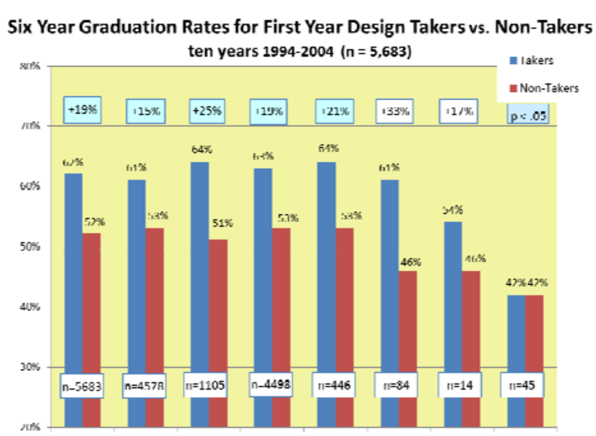
The Fuzzy Stuff - Self Efficacy

- Confidence in one's ability to perform tasks to *achieve success* in the engineering environment
- Relevance to First Year design education
  - Mastery experiences
  - Working in teams
  - Getting help
- Mastery experiences (again)
- Design!

See research of Hutchinson-Green

Self-efficacy and Persistence

- Increased persistence, achievement and interest
- Gender differences
- Relevance to First Year design
  - Experiencing
  - Confirming mastery



See Fortenberry et al

So…What Might You Ponder or Act Upon?

Jacquelyn Sullivan
College of Engineering & Applied Science
University of Colorado Boulder

Interdisciplinary Capstones

Arnold Pears
Uppsala Universitet

CeTUSS

Engineering the future

To develop the increasingly
complex systems
which support our
technological society,
and meet user expectations for flexible and usable systems,
development teams
are necessarily increasingly
interdisciplinary and intercultural
in nature.

Why interdisciplinary projects?

- Skills for a global workplace
- Competitiveness and employability
- Recent developments
  - NSF's report *"Educating Engineers as Global Citizens: A Call for Action"*
  - Global Engineering Excellence Initiative - Global Eng. Internship Program
  - Online Journal for Global Eng. Education
- European dimension of engineering education

A quote from Sherra Kerns, Olin College

Assumptions revisited:

~~2. There are single-discipline problems~~

– authentic problems cross disciplines

– fac from different disciplines teach together

– students work in teams early & often

– culminate with year-long industry problem

Olin has 3 curricula yet no academic departments.

Integrated Approaches

- Holistic PBL, e.g. Roskilde and Aalborg University, Denmark
- Interdisciplinary integrated curriculum, e.g. Olin College, USA.

Holistic approaches require high level policy support!

Capstone/Project designs

Using integrative projects is a more achievable model for many institutions

- Open Ended Group Projects (OEGP)
  (Daniels et al. 2010)

- Course level PBL
  - (A/E/C Global Teamwork)
  - (Pears and Daniels 2010)
  - (Bannerot et al. 2010)

www.CeTUSS.se

Challenges

- courses that involve students from several degree programs in an interdisciplinary context are quite hard to establish
  (Bannerot 2010)

- grading non-technical aspects is complex, and schemes vary widely
  (Dutson et al. 1997)

- interdisciplinary work practices and solution formulation are not highly regarded or appreciated
  (Pears 2009)

www.CeTUSS.se

A successful interdisciplinary project

- Integrates knowledge and skills from participants
- Builds additional competence in
  - project management
  - virtual development teamwork
  - cultural and interdisciplinary teamwork
- Allows student to experience a full project cycle from conception to delivery
- Provides opportunities to learn professional skills with close mentorship in a secure setting

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Take home messages

- Students with a strong technical focus in their studies have a tendency to under-rate the potential contribution of other key skill areas and disciplines.
- The value of skills from other disciplines are often first acknowledged after the project, during debriefing.

www.CeTUSS.se

Conclusions

- There are well established models for developing interdisciplinary teamwork skills
- Devising appropriate grading strategies is crucial
- Students need to experience interdisciplinary work at least twice during their education, since it seems that many need to experience partial failure in order to understand the value of skills with which they are unfamiliar, and have traditionally undervalued.

www.CeTUSS.se

Reflection

- Take a moment to think about the ideas, strategies, evidence and experiences presented
- Identify practices that resonate
- Start thinking about follow up

2011 ASEE Annual Conference and Exposition
Vancouver, British Columbia
Monday, June 27, 2011

Assessment of Conceptual Understanding

David L. Darmofal
Aeronautics & Astronautics
Massachusetts Institute of Technology

MIT AEROASTRO

Conceptual Knowledge

- Conceptual knowledge: "understanding of principles governing a domain and the interrelations between units of knowledge in a domain" (Perkins, 2006)
- Organization of conceptual knowledge: (Ozdemir & Clark, 2007)
  - Knowledge as theory
  - Knowledge as elements
- Misconceptions, misconceptions, misconceptions…

"*It's not what you don't know that hurts you.*
It's what you know that ain't so!"
Mark Twain

Concept Inventories

- First developed in physics to assess conceptual understanding of force and motion
  - Mechanics Diagnostic (Halloun & Hestenes, 1985)
  - Force Concept Inventory (Hestenes et al 1992)

"*Conventional physics instruction produces little change in [common sense misconceptions about mechanics] … independent of the instructor and the mode of instruction*"
(Hestenes et al 1992)

- Since the Force Concept Inventory, concept inventories have been developed in a wide-range of topics: statics, thermal & transport sciences, circuits, statistics, material science, …

- Recent work has also suggested several ways to improve the usage of concept inventories (e.g. Steif & Hansen 2007)

Oral Interviews and Exams

- Oral interviews (formative) or exams (summative) can provide rich information about how a student is thinking

- Useful to help identify misconceptions (important tool for the development of concept inventories)

- Can be time consuming and difficult to scale to large classes

- Improves likelihood of an accurate assessment by its dynamic nature

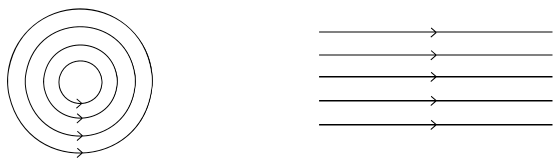
- Valuable, authentic experience for students

- Approximately half of our department's undergraduate courses use some form of oral assessments

Concept Questions & Peer Instruction

- Concept questions:
  - Focus on a single concept
  - Typically multiple choice
  - More than one plausible answer based on common misconceptions

An example from fluid dynamics on the concept of irrotationality:

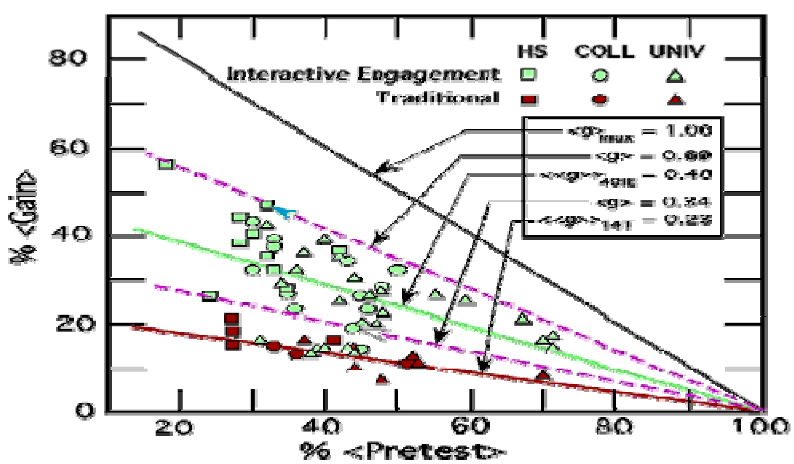


(a) (b)

Which of these flows are irrotational?

- Concept-based active learning (Peer Instruction, Mazur, 1997)

Active Learning: Twice As Effective as Lecturing

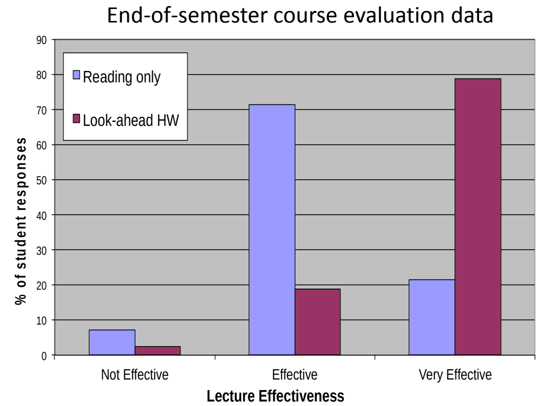


Hake, R., “Interactive Engagement vs. Traditional Methods”, Am. J. of Physics, 1998.

Student Preparation: Look-ahead Homework

(Darmofal, 2005)

- Initial implementation of concept-based lectures only gave reading assignments
- Switched to look-ahead homework due prior to discussing concepts in lecture



Typical student comments:

"*I was initially opposed to the idea that I had to do reading & homework before we ever covered the subjects. Once I transitioned I realized that it made learning so much easier!!*"

"*Doing homework before the lectures is good… makes actual learning in lectures possible.*"

SYSTEMATIC FORMATIVE ASSESSMENT

Anna Dollár, Ph.D.

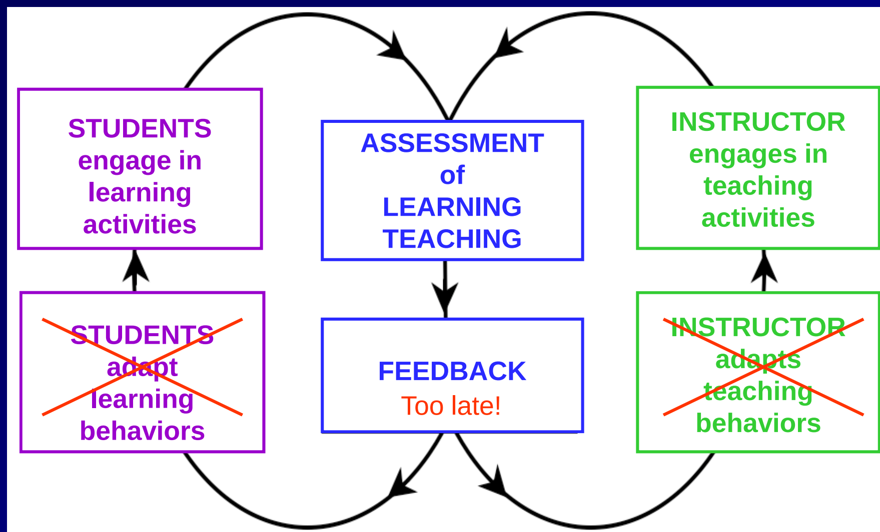
Professor

Mechanical and Manufacturing Engineering Department

MIAMI UNIVERSITY

OXFORD OHIO

Teaching / Learning System



Marsha Lovett,
Carnegie Mellon University

Summary of Findings from Research on Formative Assessments

Synthesis of over 800 meta-analyses relating to achievement:

- ranked #1 among 24 teaching approaches
- ranked #3 among 138 contributors to learning

Formative assessment is shown to be the most effective instructional intervention

Hattie J., Visible Learning, 2009

Key Lessons from Research about Formative Assessment

Assessments that promote learning provide:

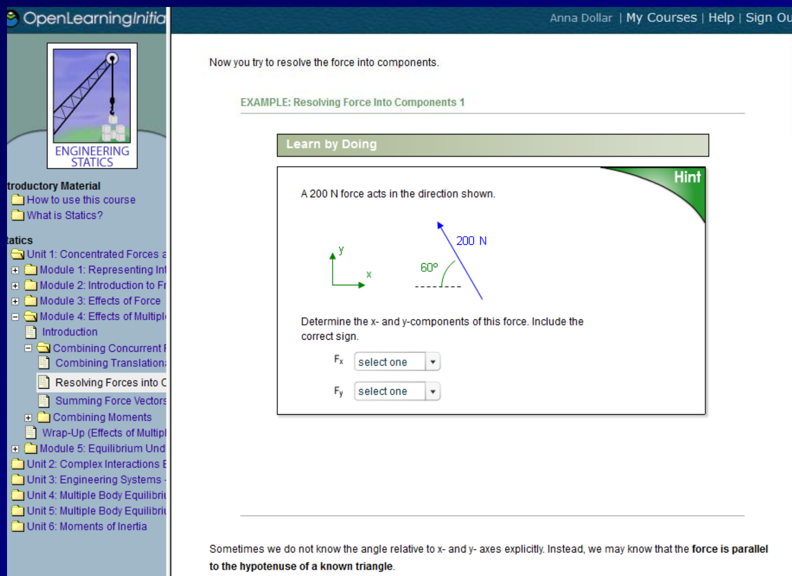
- feedback to students on their progress (non-threatening)
- feedback to instructors on both individual and class performances
- opportunities to close the gap between current & desired performance

Ambrose at al., (2010), *How Learning Works: Seven Research-Based Principles for Smart Teaching*

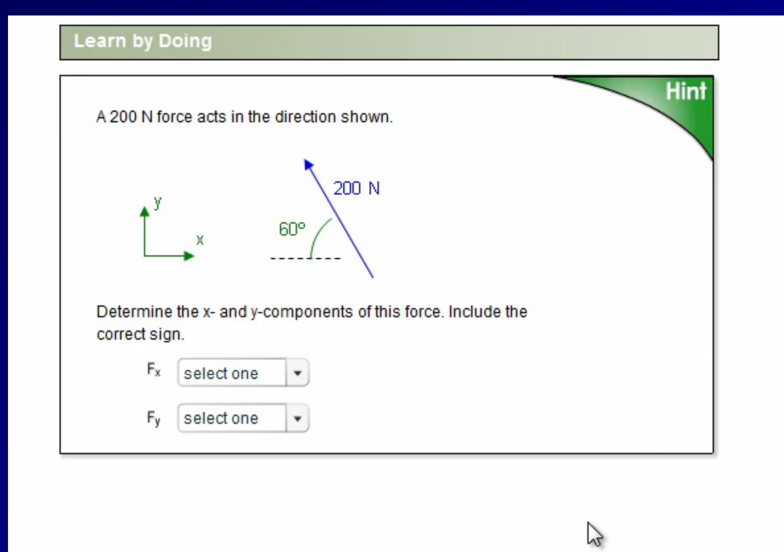
Example: Open Learning Initiative (OLI) Engineering Statics

- Part of CMU's Open Learning Initiative
- Free online courseware with over 300 interactive exercises with formative & summative assessments http://oli.web.cmu.edu/openlearning/
- Co-authored by:
  - Paul S. Steif, Carnegie Mellon University
  - Anna Dollár, Miami University

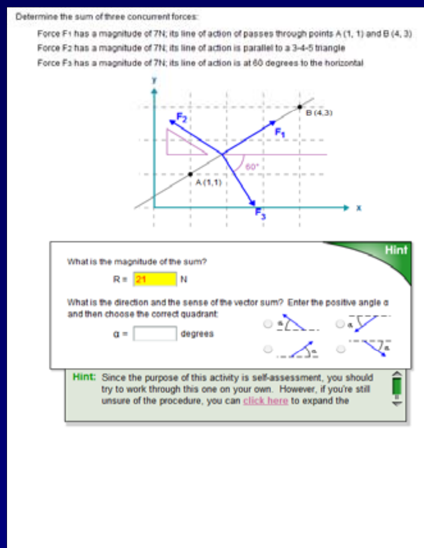
Example of an Interactive Exercise with Feedback

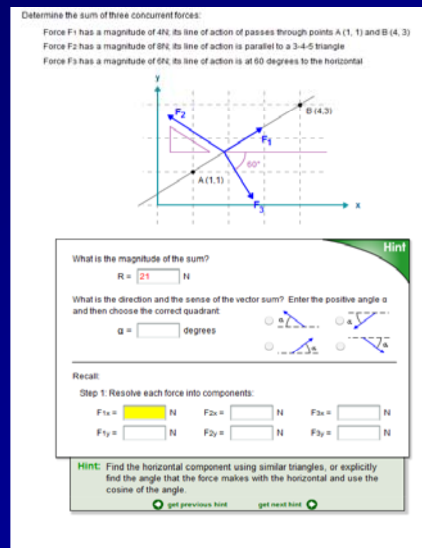


Example of an Interactive Exercise with Feedback and Hints



Example of an Interactive Exercise with Feedback and Scaffolding





Concept of an Inverted Classroom

Traditional, lecture-based classroom:

- students come to class unprepared
- listen passively to lecture

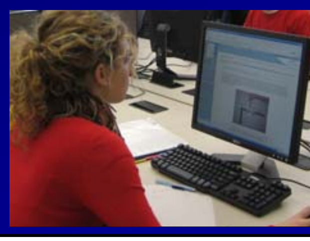
Inverted classroom:

- first contact with new material and initial formative assessments take place outside of classroom
- students come to class prepared to be actively engaged

OLI-Statics in Inverted Classroom

Students are required (before class) to:

- complete modules with Interactive Exercises
  - – self-regulated, based on formative assessment (not graded)
- take end of module quiz (low stake grades)
- write feedback to instructor:
  - o which concepts/ skills were the most difficult
  - o questions for the instructor to address in class



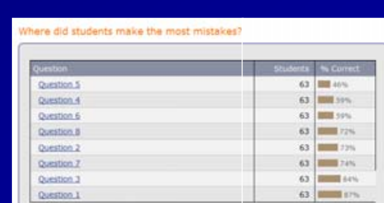
OLI Engineering Statics Learning Dashboard for Instructor

Interactive Exercises

- aggregated data on class usage
- individual students' completion rates
- individual questions' reports

Quizzes

- online quizzes' results
- individual quiz questions' reports


Where did students make the most mistakes?

Question	Students	% Correct
Question 5	63	46%
Question 4	63	59%
Question 6	63	59%
Question 8	63	72%
Question 2	63	73%
Question 7	63	74%
Question 3	63	84%
Question 1	63	87%

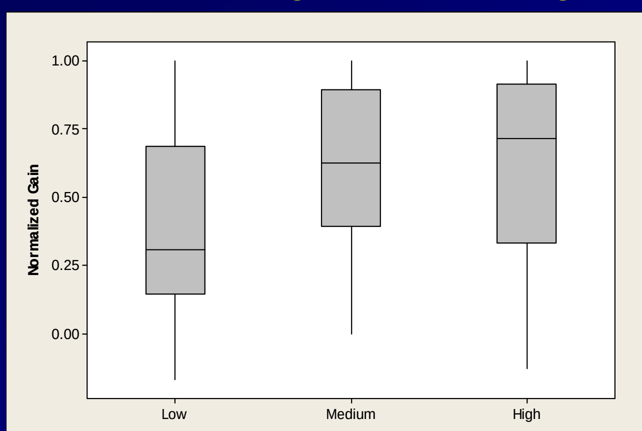
Students' written feedback

OLI Engineering Statics
Classroom Strategy using Learning Dashboard

Instructor:

- **prior to class studies LD reports to:**
  - identify common student difficulties
  - adjust the classroom strategy
- **devotes class time to specific topics, concepts, and skills that need elaboration and reinforcement**
  - exercises causing most difficulties
  - quiz questions on which scores are low
  - questions raised by many students
- **provides more opportunities for practice**

Studies of Usage and Learning Gains



Box plot of normalized gains for groups of students who had completed low, medium, and high numbers of tutors

Steif, P. S., Dollár, A.
Study of usage patterns and learning gains in a web-based interactive static course. JEE, 2009

Reflection

- Take a moment to think about the ideas, strategies, evidence and experiences presented
- Identify practices that resonate
- Start thinking about follow up

Follow Up Sessions and Next Steps

JEE Centennial

- M722A - A Celebration of the Engineering Education Research Community (ERM)
  - Mon. June 27, 2011 6:00 PM to 8:00 PM, Vancouver International Conference Centre, East Building - Room 14

Jamieson & Lohmann Report

- W304B - Distinguished Lecture: Creating a Culture for Scholarly and Systematic Innovation in Engineering Education: Final Report of a Multi-Year Initiative (ASEE Board of Directors)
  - Wed. June 29, 2011 10:30 AM to 12:00 PM, Vancouver International Conference Centre, 122

Explore Resource Web Site and Talk with Presenters