L’esempio TEAL - Technology Enabled Active Learning

Seminario di Formazione
AULA 3.0
UNA POSSIBILE RISPOSTA ALLA SCUOLA DEL FUTURO

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MIT Experiment in Active Learning

(Technology Enabled Active Learning)

TEAL Ten Year Ongoing Experiment at:

A merger of presentations, tutorials, and hands-on laboratory experience into a technologically and collaboratively rich environment

Topics

Why Change to TEAL?

Components of Active Learning

Assessment and Sustainability

Resources

Goals of Science and Engineering Education

Develop next generation of scientists, engineers, and teachers

Develop scientific literacy so that the next generation is capable of making informed decisions on issues arising from complex systems

Develop expert problem solvers to tackle complex problems that face society

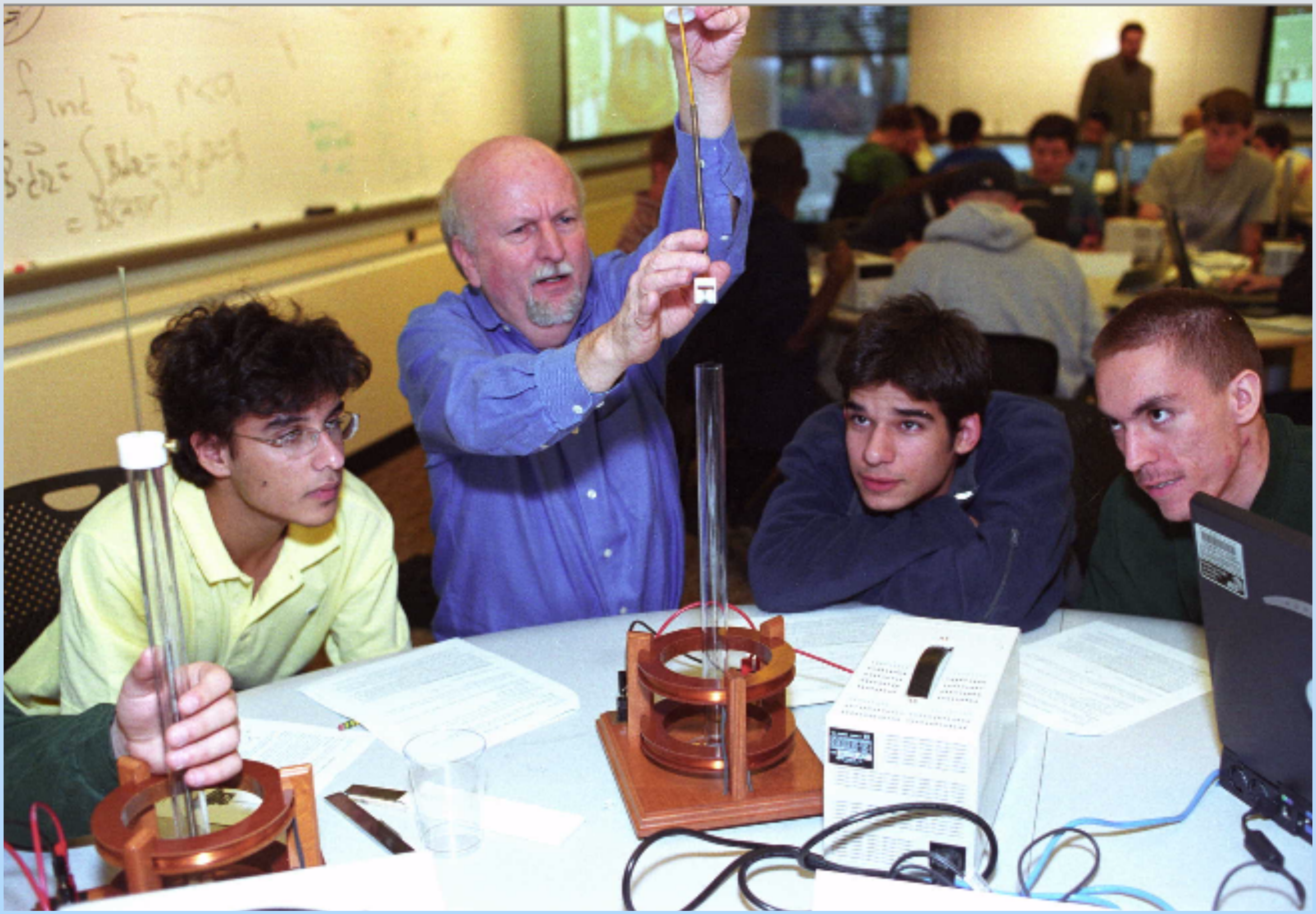
Develop intellectual curiosity about scientific thought

Why The TEAL/Studio Format?

Large first-year physics courses have inherent problems

1. Lecture/recitations are passive
2. Low attendance
3. High failure rate
4. Math is abstract, hard to visualize (esp. Electricity and Magnetism)
5. No labs leads to lack of physical intuition

Teacher/Student Interaction



Prof. John Belcher TEAL Founder

TEAL Time Line

Models:

RPI's Studio Physics (Jack Wilson)

NCSU's Scale-Up (Bob Beichner)

Harvard Peer Instruction (Mazur)

Fall 2001-2
Prototype
Off-term E&M 8.02

Spring 2003-Present
Scaled-up
E&M 8.02

Fall 2003-4
Prototype
Mechanics 8.01

Fall 2005-Present
Scaled-up
Mechanics 8.01

Learning Objectives

Broad Educational Learning Objectives

- Move away from passive lecture format to active studio learning environment
- Develop communication skills in core sciences
- Develop collaborative learning
- Encourage undergraduates to teach
- Develop new teaching/learning resources based on scientific standards of research

Specific Learning Objectives

- Enhance conceptual understanding
- Enhance problem-solving abilities
- Incorporate hands-on experiments that develop project-based/research lab learning skills

Learning Place

Learning Place: Design Principles

Architectural design based on

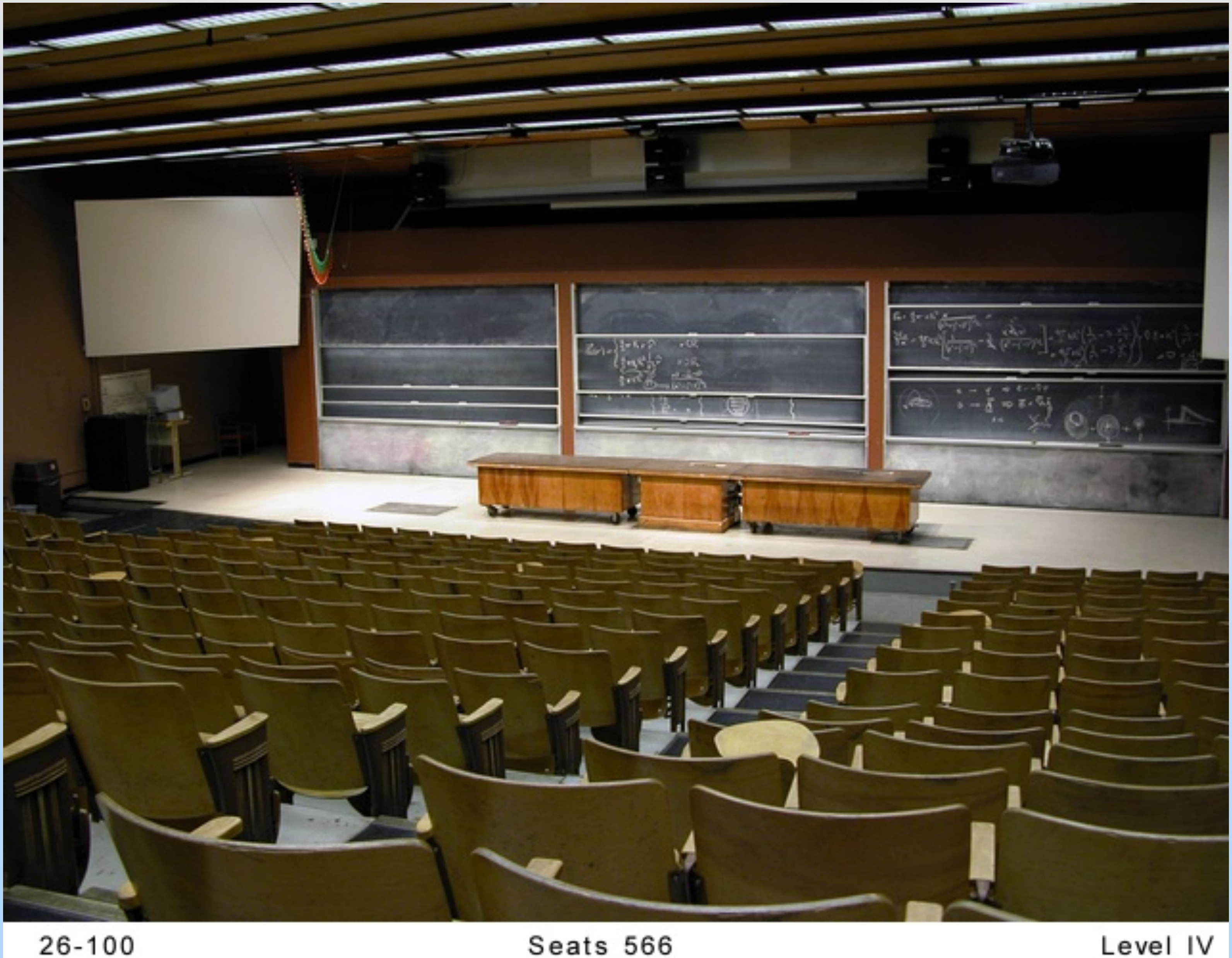
1) How people interact and learn

2) Pedagogical model

Olympic Learning Space

Photo: Sergio Moraes/Reuters

The starting point
1918



The lecture hall I learned in and still there today

Trying to have it both ways

Transforming the Learning Space: TEAL Classroom

Collaborative learning (Modeled after NCSU's Scale-Up Classroom)

9 Students work together at each table of 9 students each

Form groups of 3 students that work collaboratively

Course Design

Traditional Course Design

Course Content

Assessment

Result: **Course Defined by Content**

Backwards Course Design

Desired Outcomes: Learning Objectives

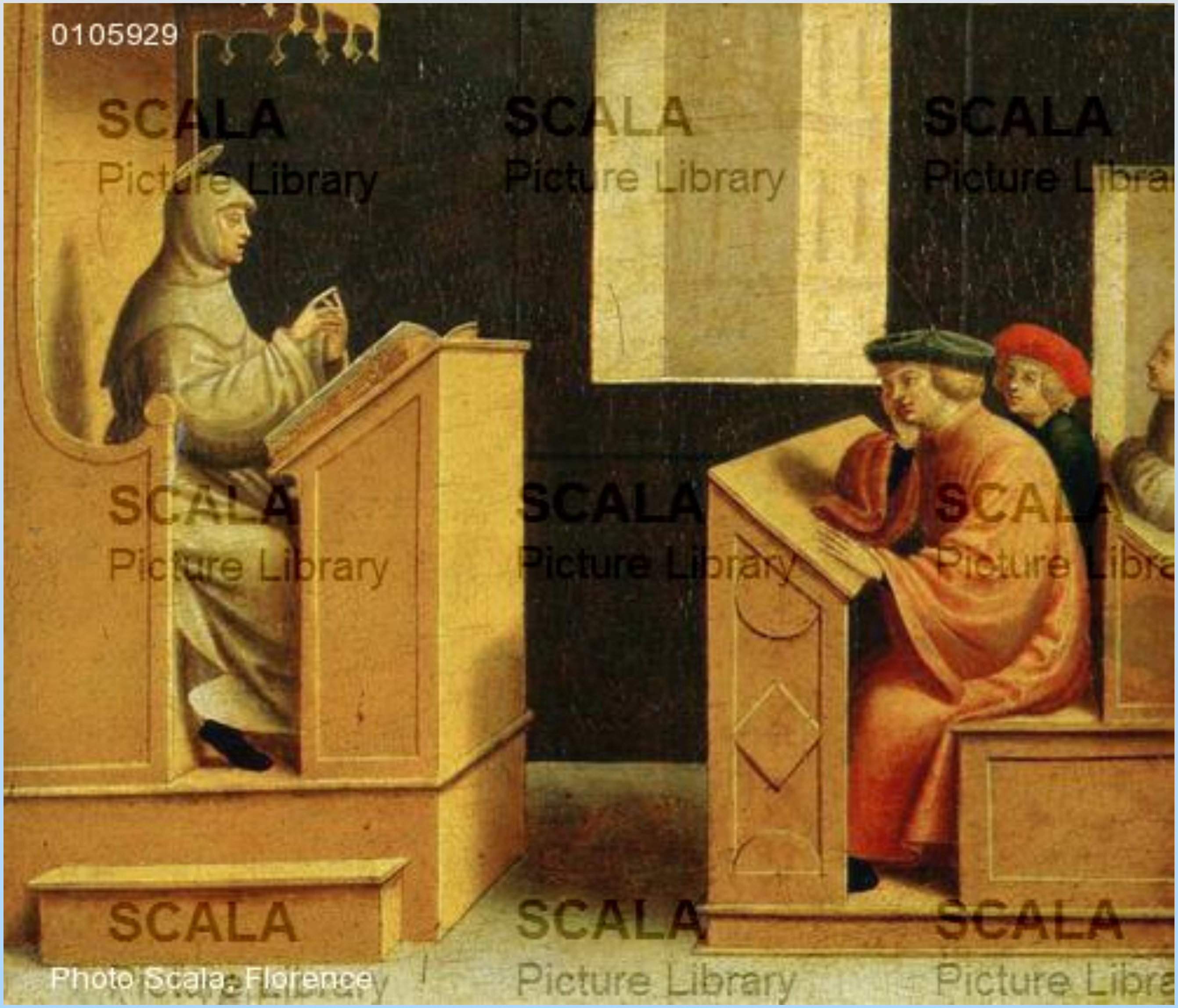
Acceptable Evidence

Instructional Approach

Result: **Course Content Determined by Outcomes**

Rethinking Teaching Roles

Traditional Teaching: Lecturing



Rethinking Teaching Roles

Rethinking Teaching Roles

Instructor no longer delivers material but focuses on student learning

Measures learning outcomes

Motivates student and instills passion for learning

Rethinking Teaching Roles

Instructor: No longer delivers material but insures students learn material

Graduate TA: Learn to teach

Undergraduate TA: Encourages student teaching

Technical Instructor: No longer hidden

Students: Peer Instructors

TEAL in Action

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

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Active Learning

Components of Active Learning Class: TEAL

- Interactive Presentations with Demos
- On-line Visualizations
- ConcepTests: Peer Instruction with Clickers
- Desktop Experiments
- Extensive Problem Solving Opportunities

Group Learning

Advantages of Groups

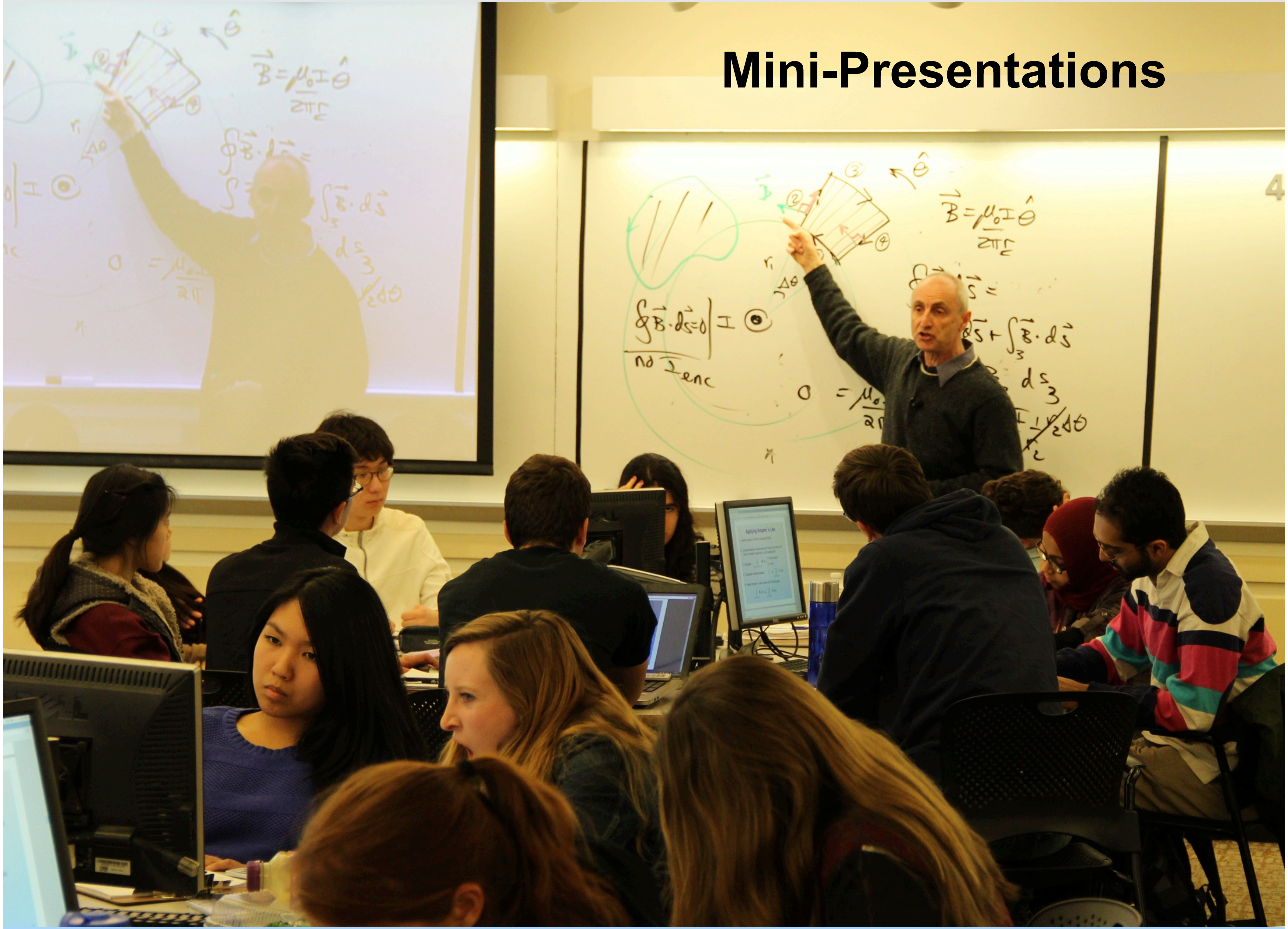
- Three heads are better than one
- Don’t know? Ask your teammates
- Do know? Teaching reinforces knowledge
- Practice for real life – science and engineering require teamwork; learn to work with others

What Groups Aren’t

A Free Ride.

If you don’t contribute you don’t get credit.

Mini-Presentations



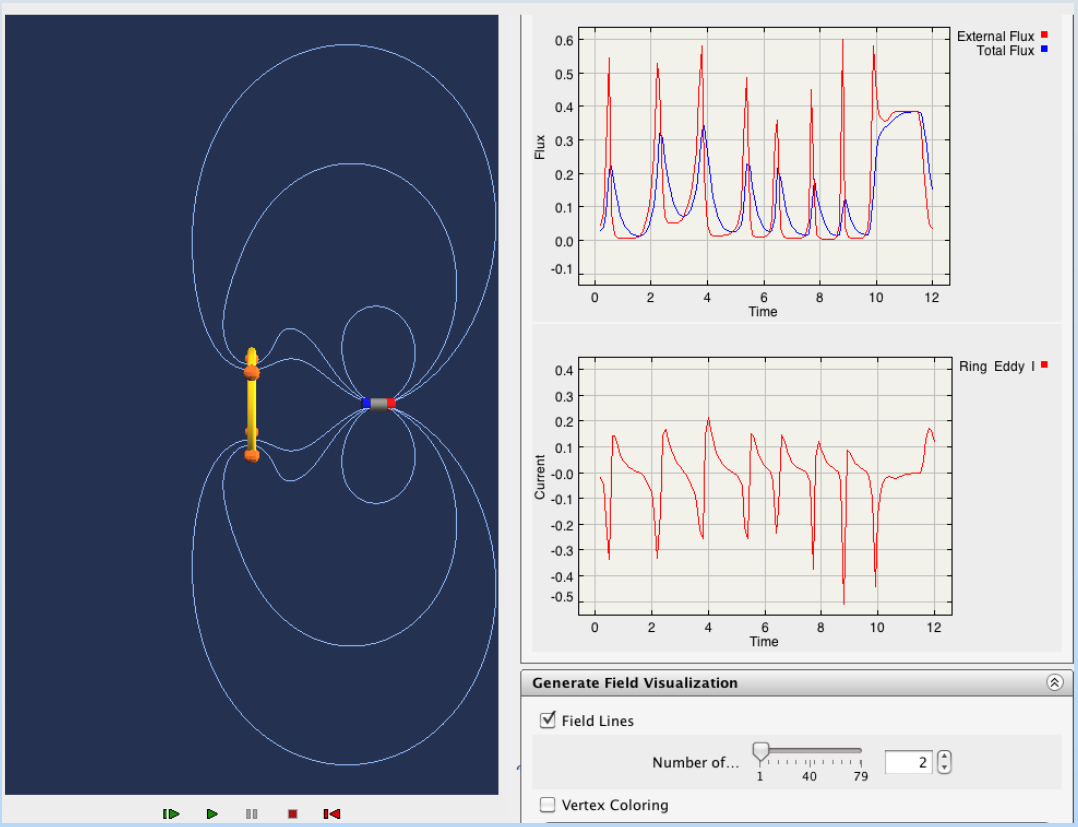
Lecture Demonstrations

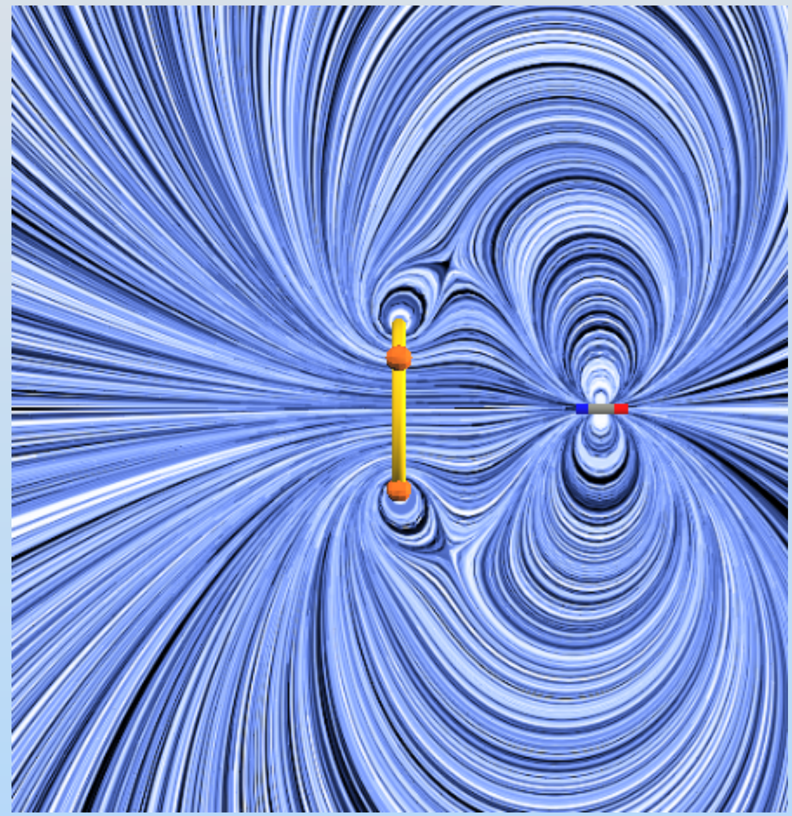
Desk-Top Experiments

Networked laptops with data acquisition links between laptop and experiments

Visualizations and Simulations

Visualizations and Simulations Discovery Activity

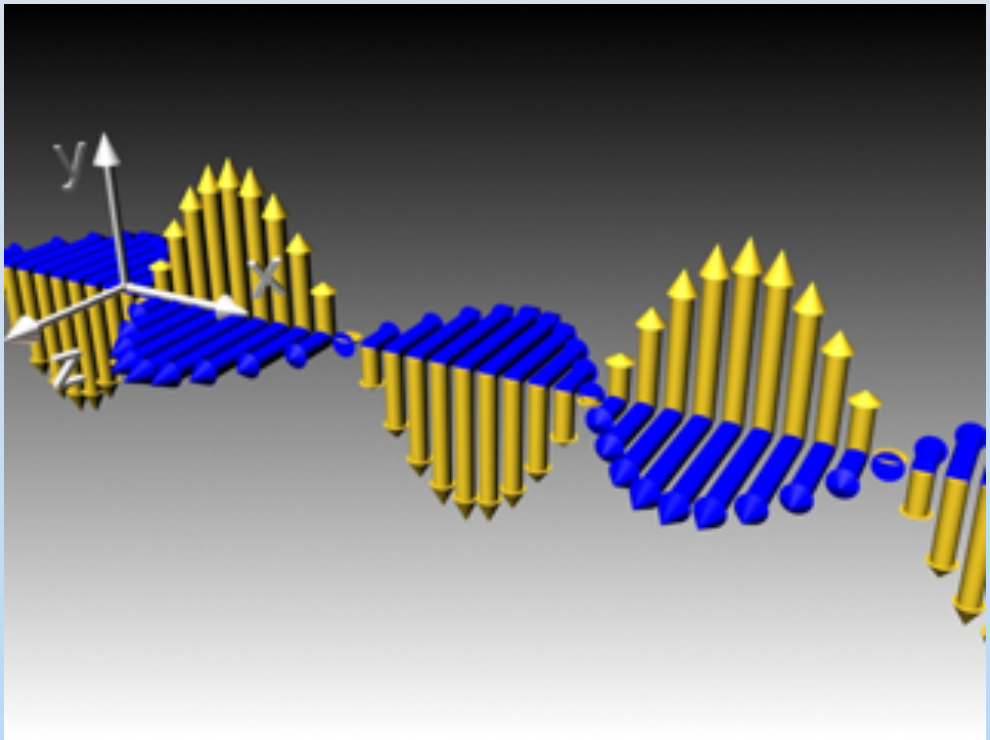




Changing magnetic flux induces current

http://web.mit.edu/viz/EM/visualizations/faraday/faradaysLaw/faradayapp/faradayapp.htm

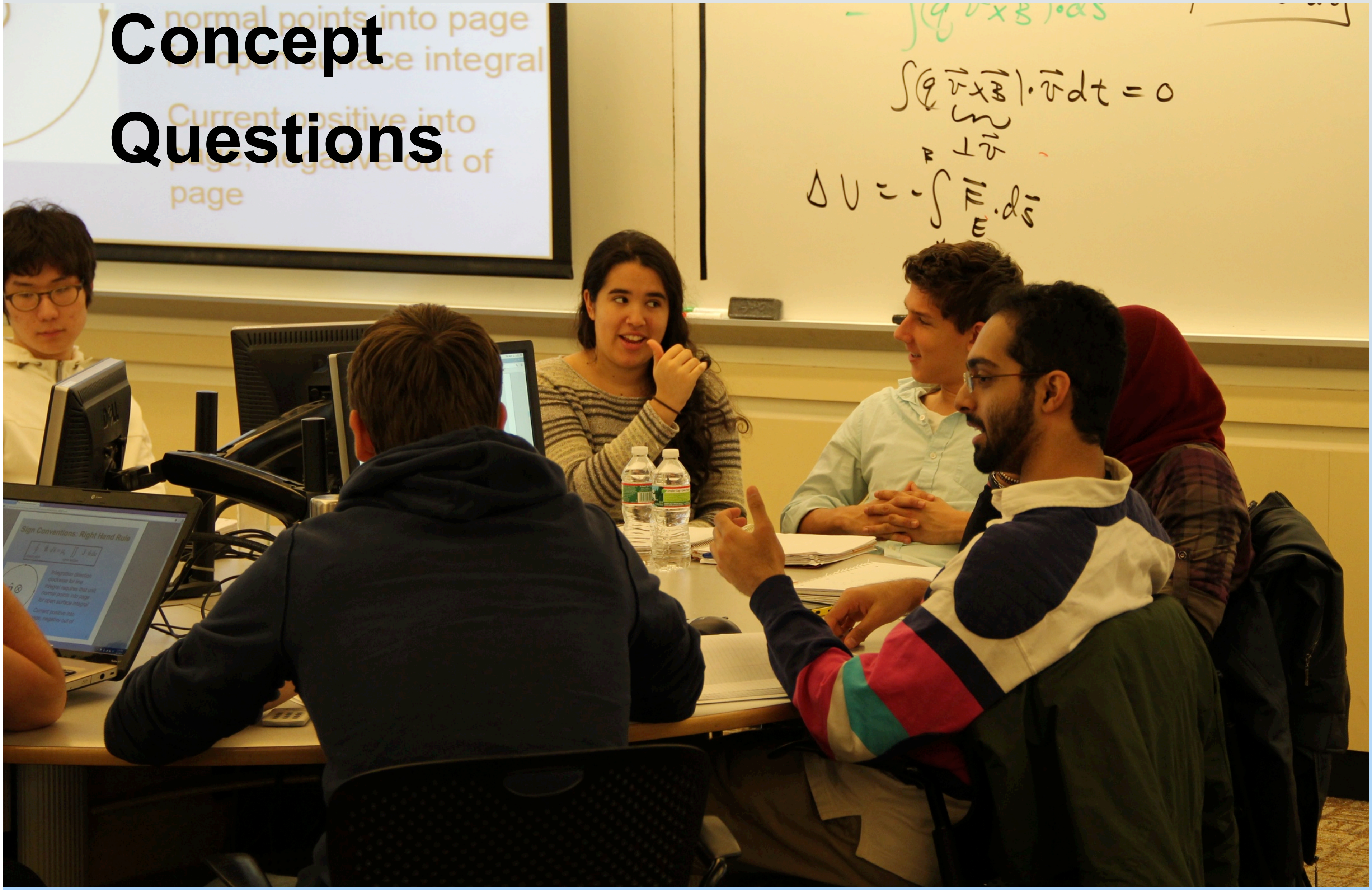
Visualizations and Simulations: Develop Conceptual Understanding



Traveling Electromagnetic Plane Wave

http://web.mit.edu/viz/EM/visualizations/light/EBlight/EBlight.htm

Concept Questions



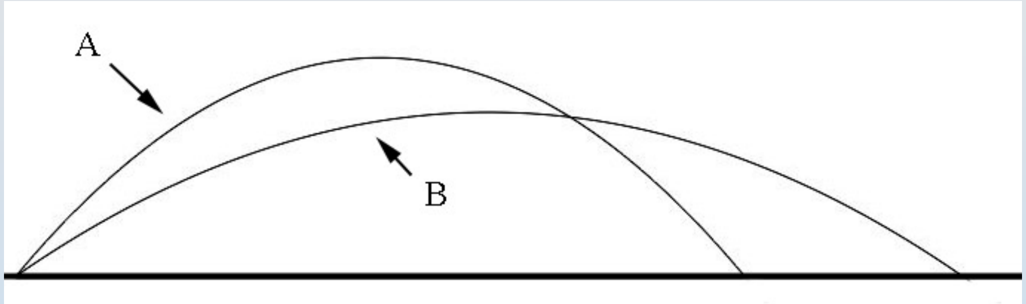
ConcepTests / Peer Instruction

Model: Eric Mazur's Peer Instruction based on ConcepTests using "Clicker" Technology

Methodology:

- Concept Test
- Thinking
- Individual answer
- Feedback: Just in Time Teaching
- Peer discussion
- Revised group answer
- Explanation

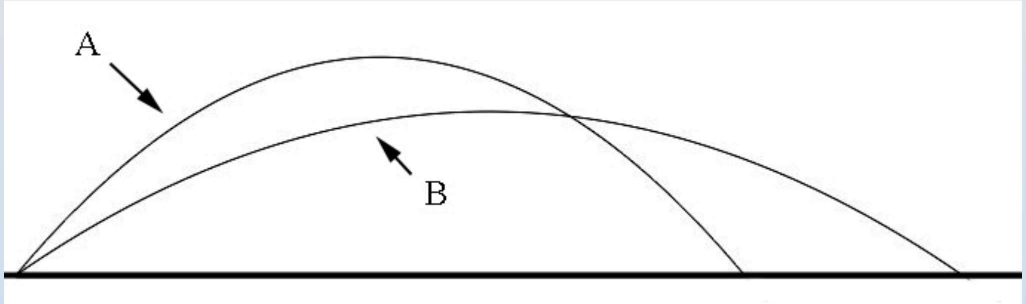
Concept Q.: Which Hits First?



A person simultaneously throws two objects in the air. The objects leave the person's hands at different angles and travel along the parabolic trajectories indicated by A and B in the figure below. Which of the following statements best describes the motion of the two objects? Neglect air resistance.

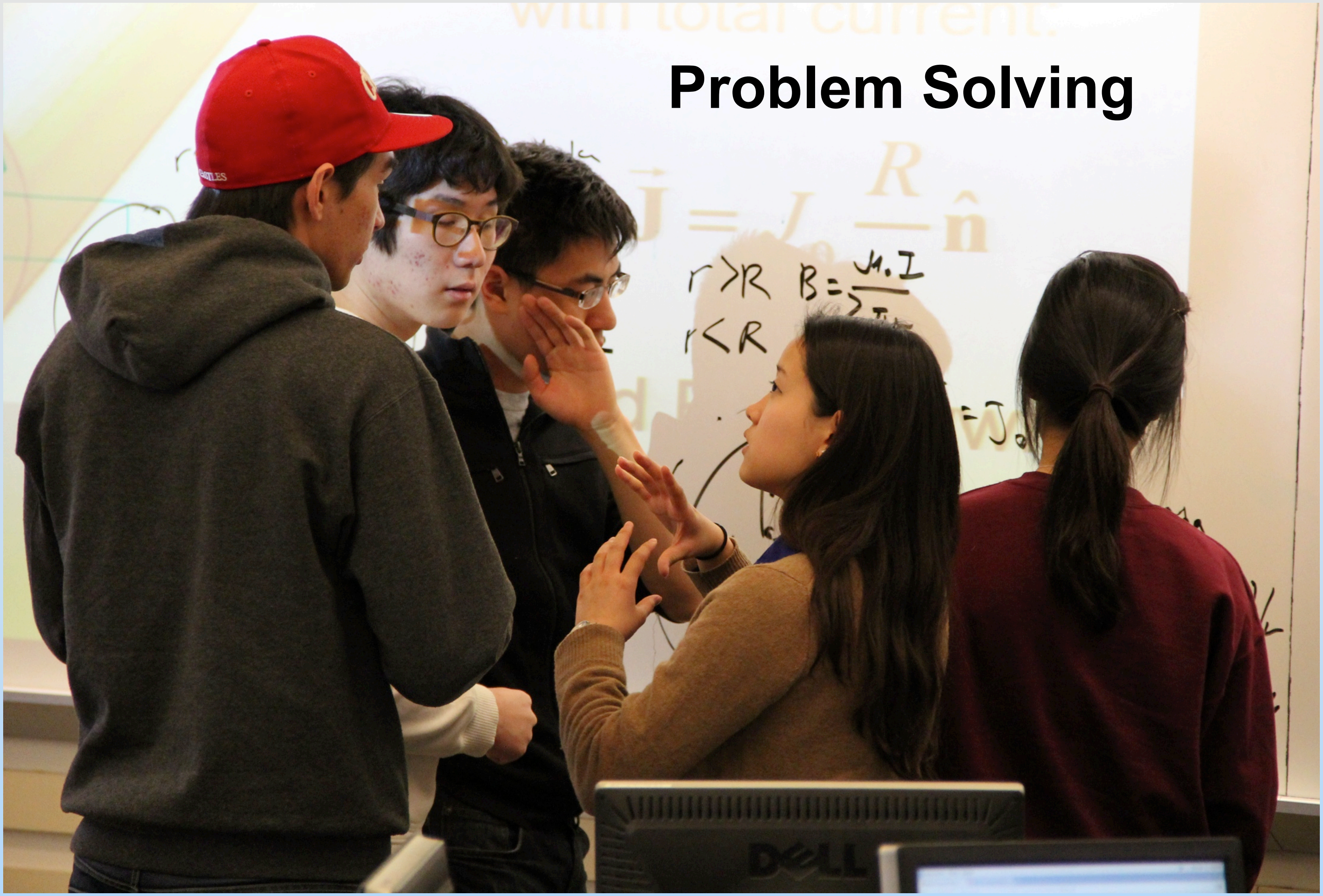
1. The object moving along the trajectory A hits the ground before the object moving along the trajectory B.
2. The object moving along the higher trajectory A hits the ground after the object moving along the lower trajectory B.
3. Both objects hit the ground at the same time.
4. There is not enough information specified in order to determine which object hits the ground first.

Which Hits First? Answer



Answer: 2. Begin by assuming that we can ignore the effects of air resistance. Then it will take the same amount of time to reach the top of the trajectory as it takes to return to the starting height (in this case approximately the ground). If you drop two objects at the same time from two different heights, the object released from the higher height will reach the ground later. Therefore object A that is moving along the higher trajectory will hit the ground after object B which is traveling along the lower trajectory.

Problem Solving



Students take turns writing up their work

Students work in small teams at the white boards solving problems

Problem Solving

MIT student will solve approximately 10,000 problems in four years

Students learn to become expert problem solvers

Develop confidence based on experience

Necessary for innovation and creative thinking

Expert Problem Solver

Learn to Think Like a Physicist

- Factual and procedural knowledge
- Knowledge of numerous models
- Skill in overall problem solving.

Problems should not ‘lead students by the nose” but integrate synthetic and analytic understanding

Beginner Problem Solvers

- Unable to represent physical concepts
- Unable to combine multiple ideas
- Unable to apply mathematical reasoning
- Engage in symbol manipulation
- Unable to estimate and make ‘back of the envelope’ calculations

Table Problem: Free Kick

A player kicks a football, which lies at rest on the ground, into the air with an initial speed, v_0 = 20 m/s , and makes an angle θ_0 = 30^o with respect to the horizontal. How far downfield does the ball hit the ground? When the ball is in flight, ignore all forces acting on the ball except for gravitation. Let g = 9.8 m/ s^2.

Discussion Question: If a player heads the ball in the opposite direction just before it hits the ground, estimate the force of the ball on the head.

Sustainability

Sustainability

1. Guarantee institutional support
2. Adapt teaching to local institutional / faculty / student cultures
3. Address faculty concerns regarding active based learning
4. Develop student support by explanation of learning goals

Assessment

Research Instruments

Assessing Variables	Instruments
Problem Solving	Tests with quantitative problems
Conceptual Understanding	1. Pre-tests and post-tests 2. Spatial tests
Attitudes	1. Mid-term & post-term questionnaires 2. Focus discussion group

Pre/Post Conceptual Test Scores Relative Improvement Measure

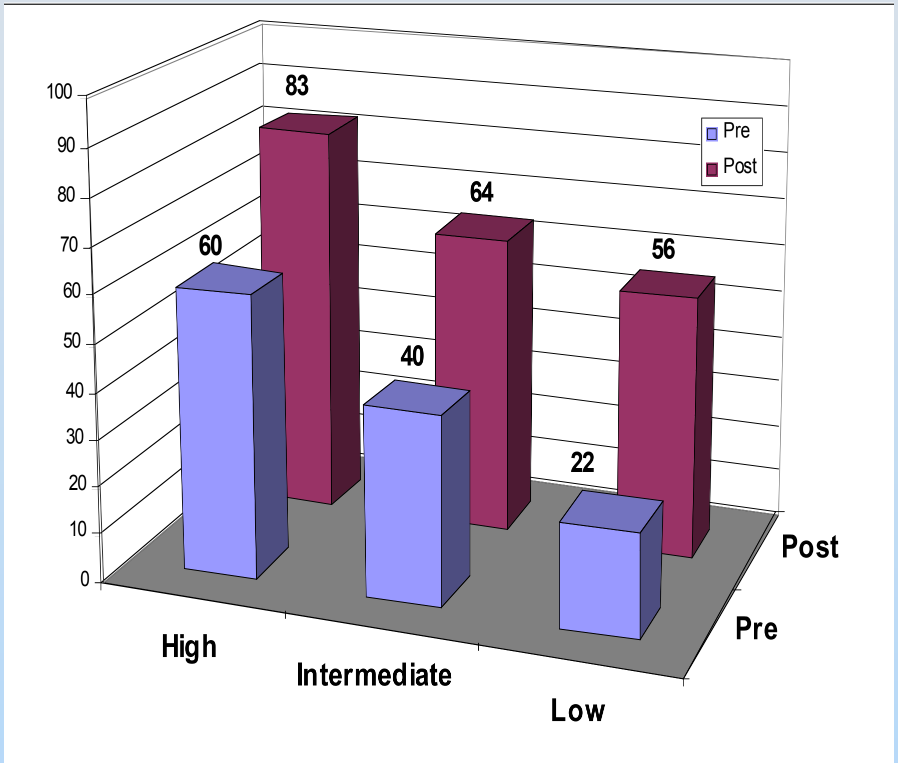
$$\langle g \rangle = \left(\frac{\%\text{Correct}_{post-test} - \%\text{Correct}_{pre-test}}{100 - \%\text{Correct}_{pre-test}} \right)$$

Hecke
g-factor

Group	Trial 2001		Control 2002		Spring 2003	
	N	g	N	g	N	g
Entire population	176	0.46	121	0.27	514	0.52
High	58	0.56	19	0.13	40	0.46
Intermediate	48	0.39	50	0.26	176	0.55
Low	70	0.43	52	0.33	300	0.51

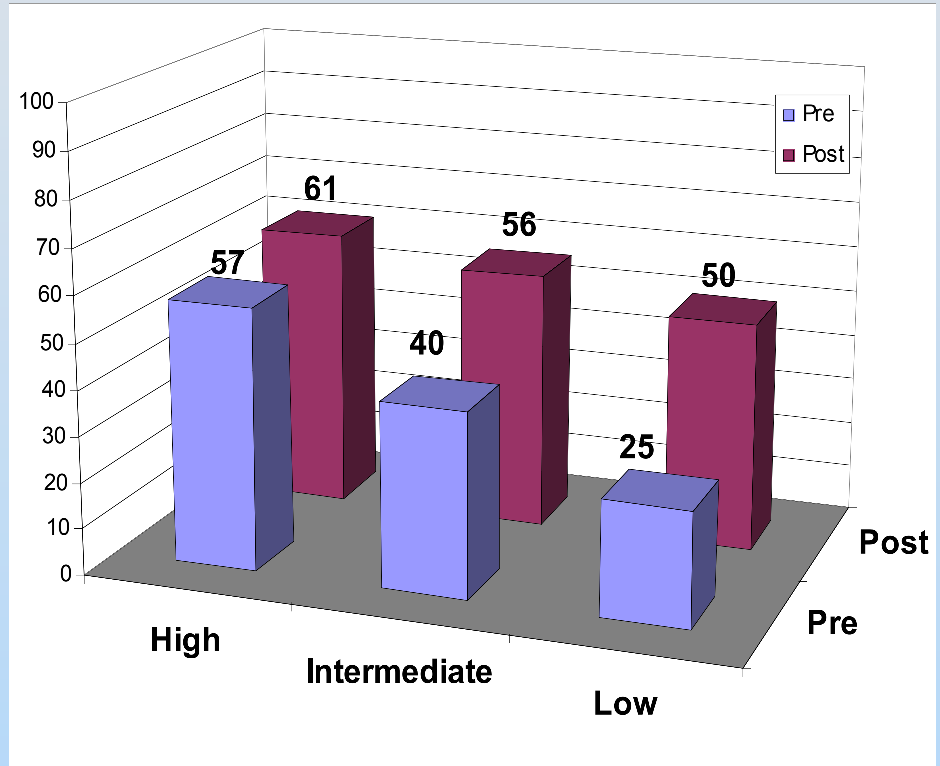
Pre-Post Concept Test Scores

N students = 176



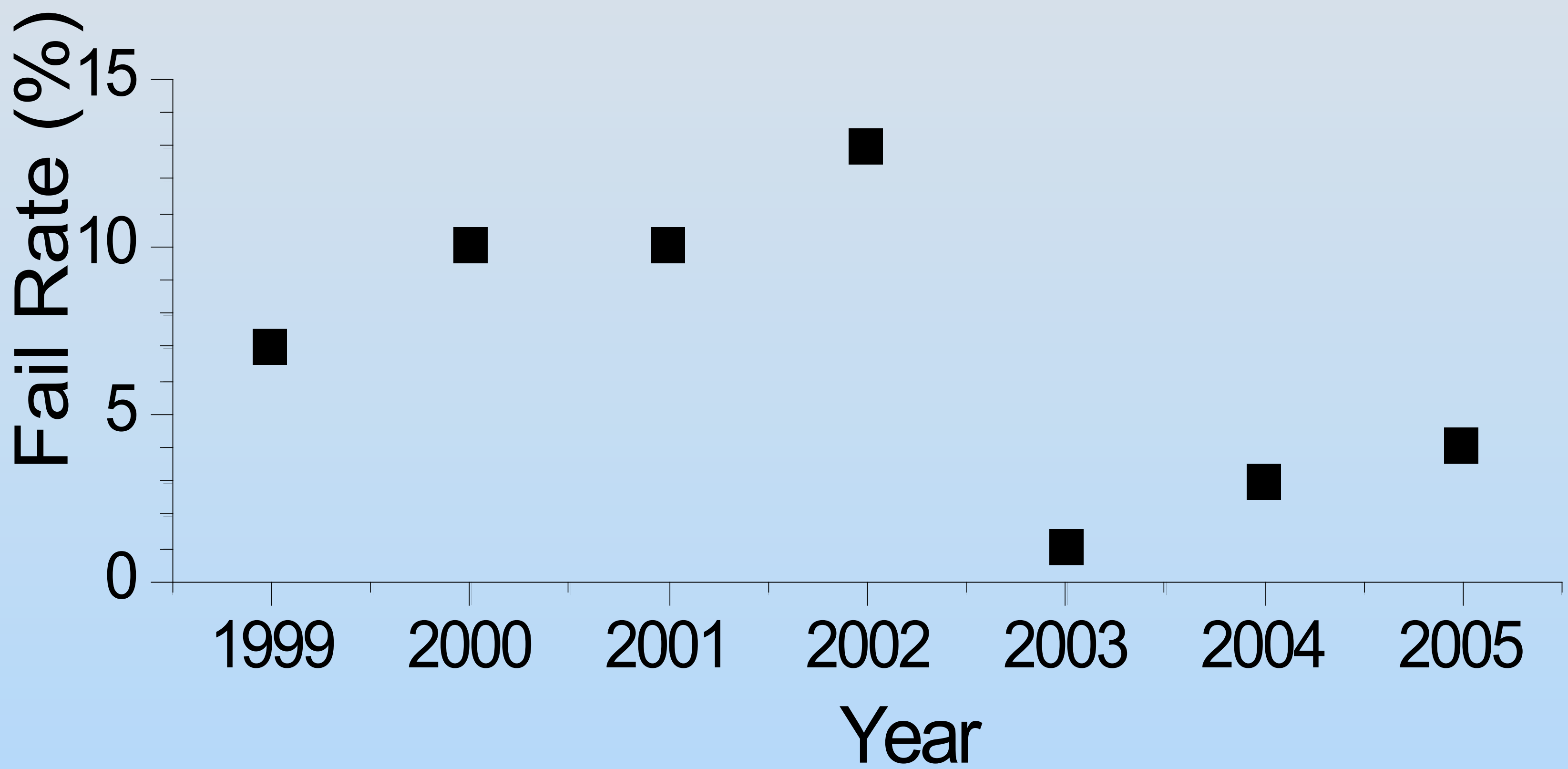
Experimental group - Fall 2001

N students = 121

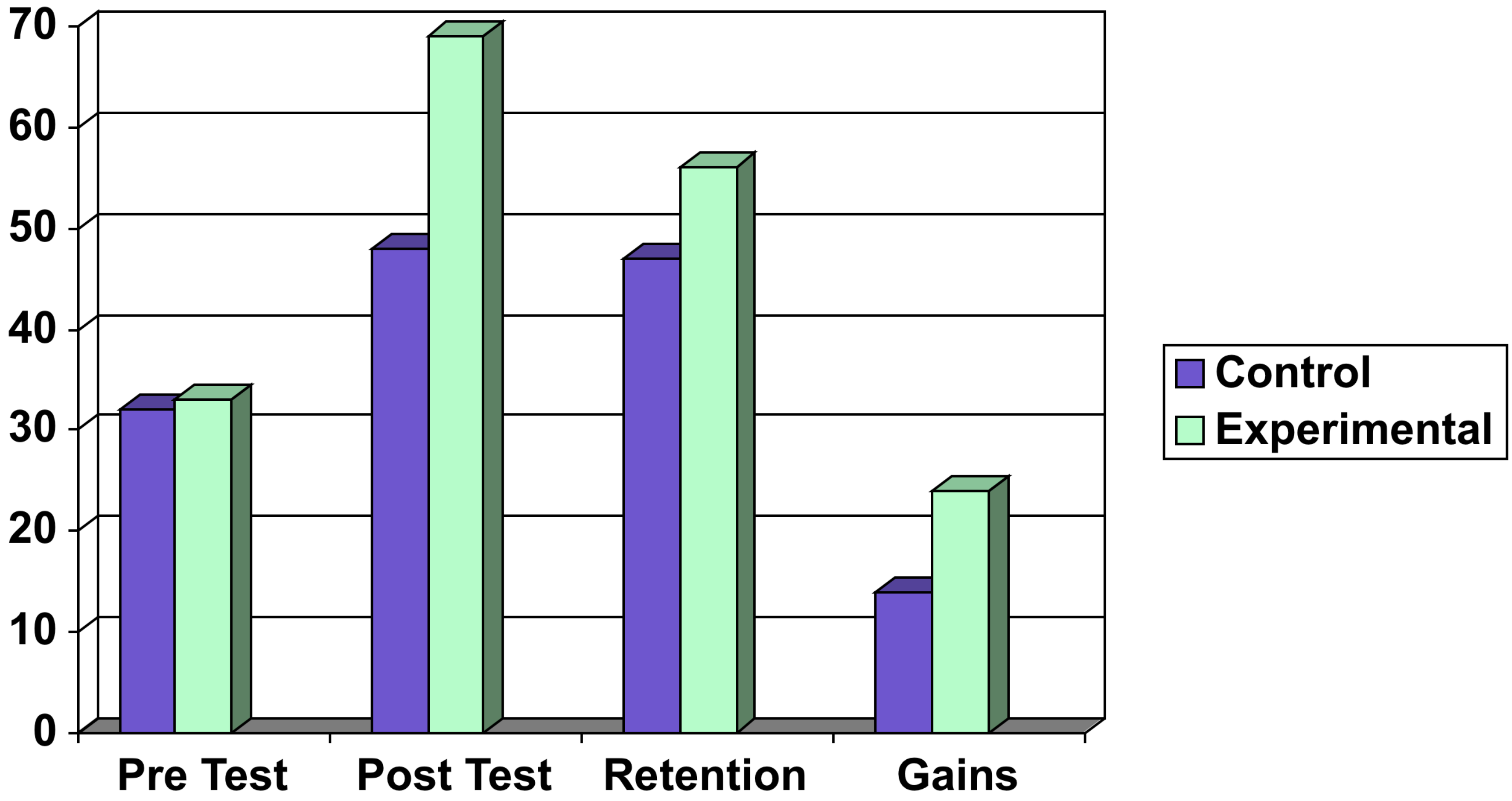


Control group - Spring 2002

E&M Lower Failure Rate



Increases Seen Long Term



- Source: Dori, Y.J., E. Hult, L. Breslow, & J. W. Belcher (2005). "The Retention of Concepts from a Freshmen Electromagnetism Course by MIT Upperclass Students," paper delivered at the NARST annual conference.

Sustainability

1. Establish rotating faculty administrators
2. Support resource development team
3. Support teacher training program
4. Regular evaluation by department
5. Incorporate results of assessment

Research Based Teaching

- Develop specific learning objectives
- Create rigorous means to measure the actual objectives.
- The methods and instruments for assessing the objectives must satisfy the same criteria, as is done in scientific research