

# **Peer Instruction: Methods and Techniques**

**Suvendra Nath Dutta  
Mazur Group & DEAS IT Group  
Division of Engineering & Applied Sciences  
Harvard University**



**Ohio University  
6 June 2003**



# *Outline*

## ► **Problem**

Classes focused at future professional  
Physicists

## ► **Cause**

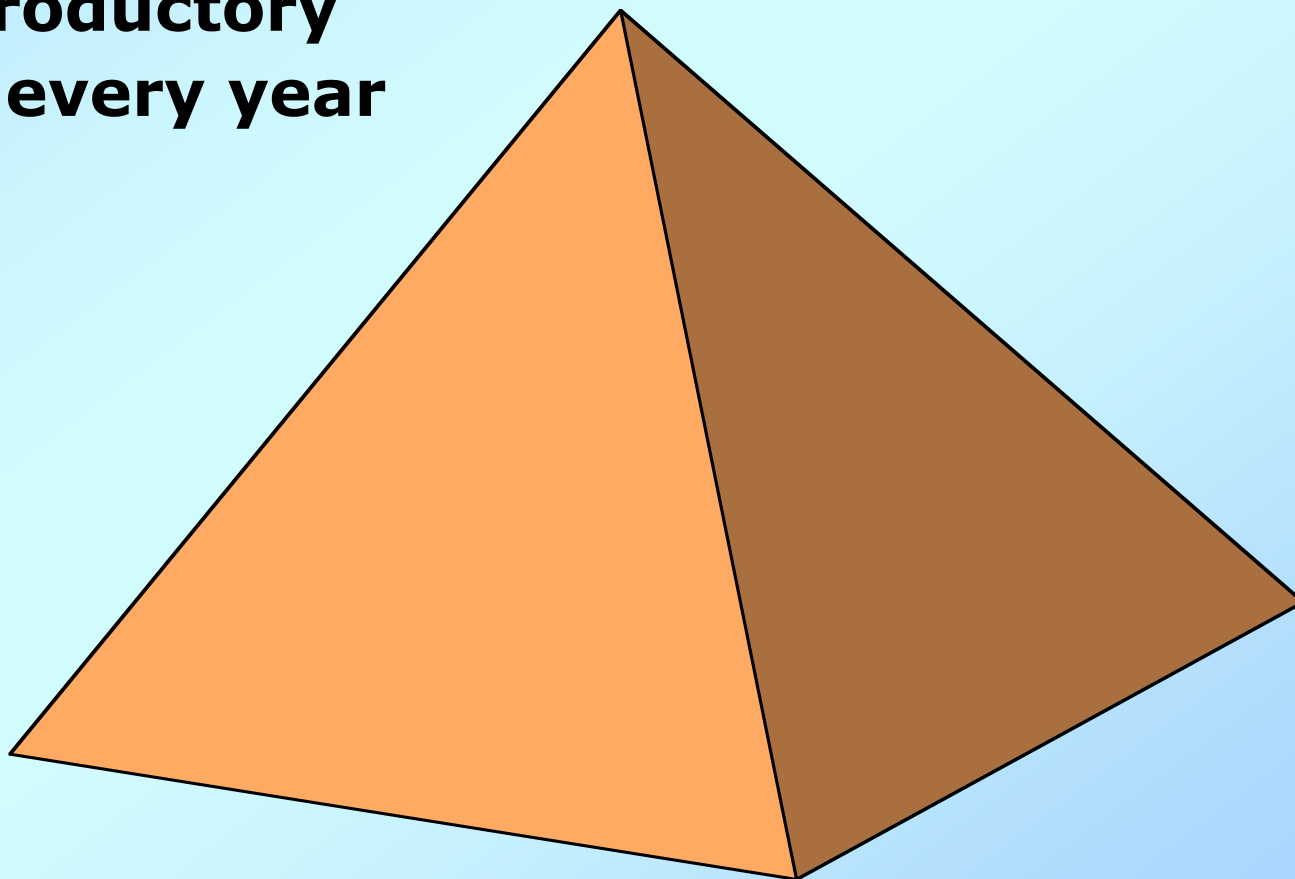
High bandwidth, unidirectional flow of  
information

## ► **Solution**

An interactive classroom

# ***Problem***

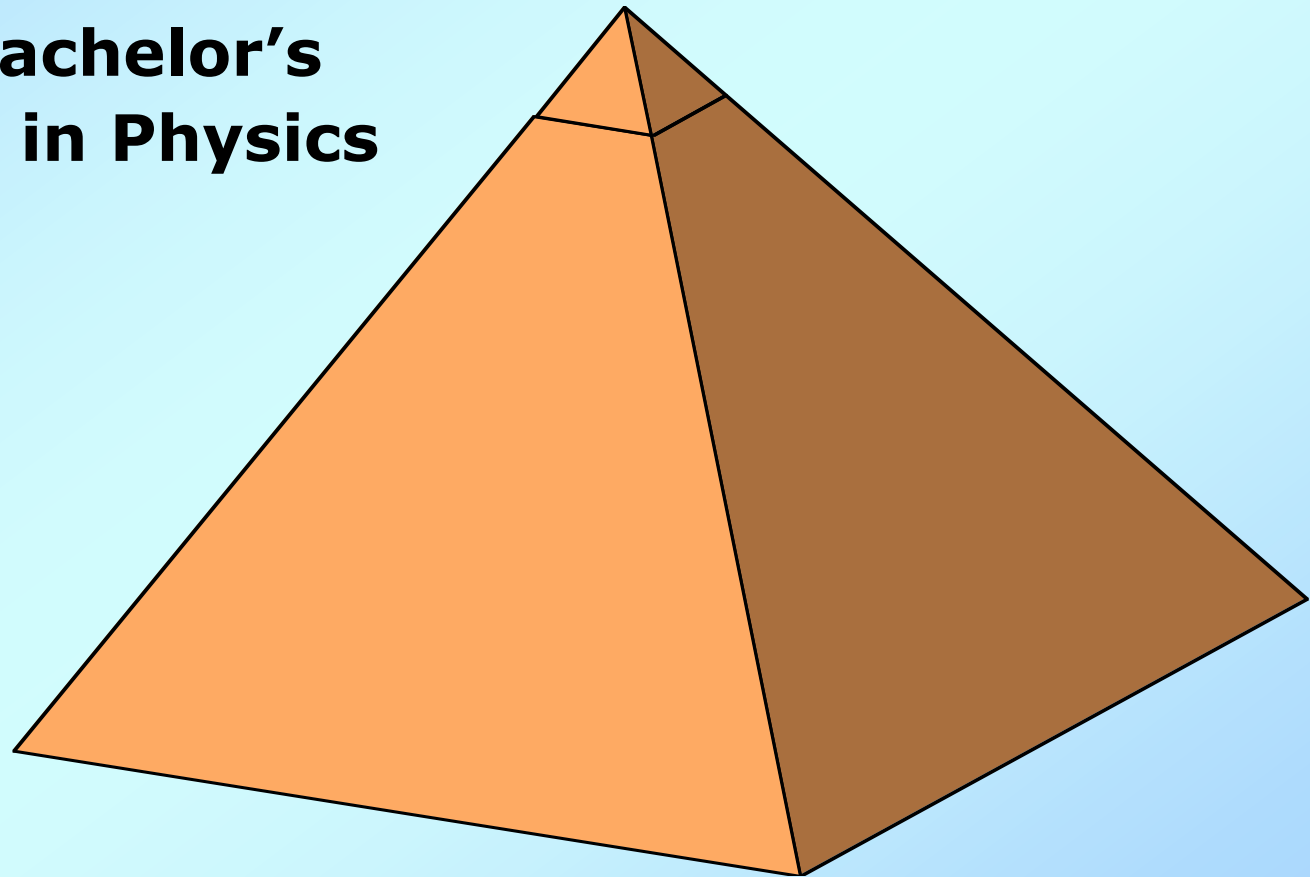
- ▶ **380,000 students  
take introductory  
Physics every year**



***AIP Report R-151.33 (1997)***

# ***Problem***

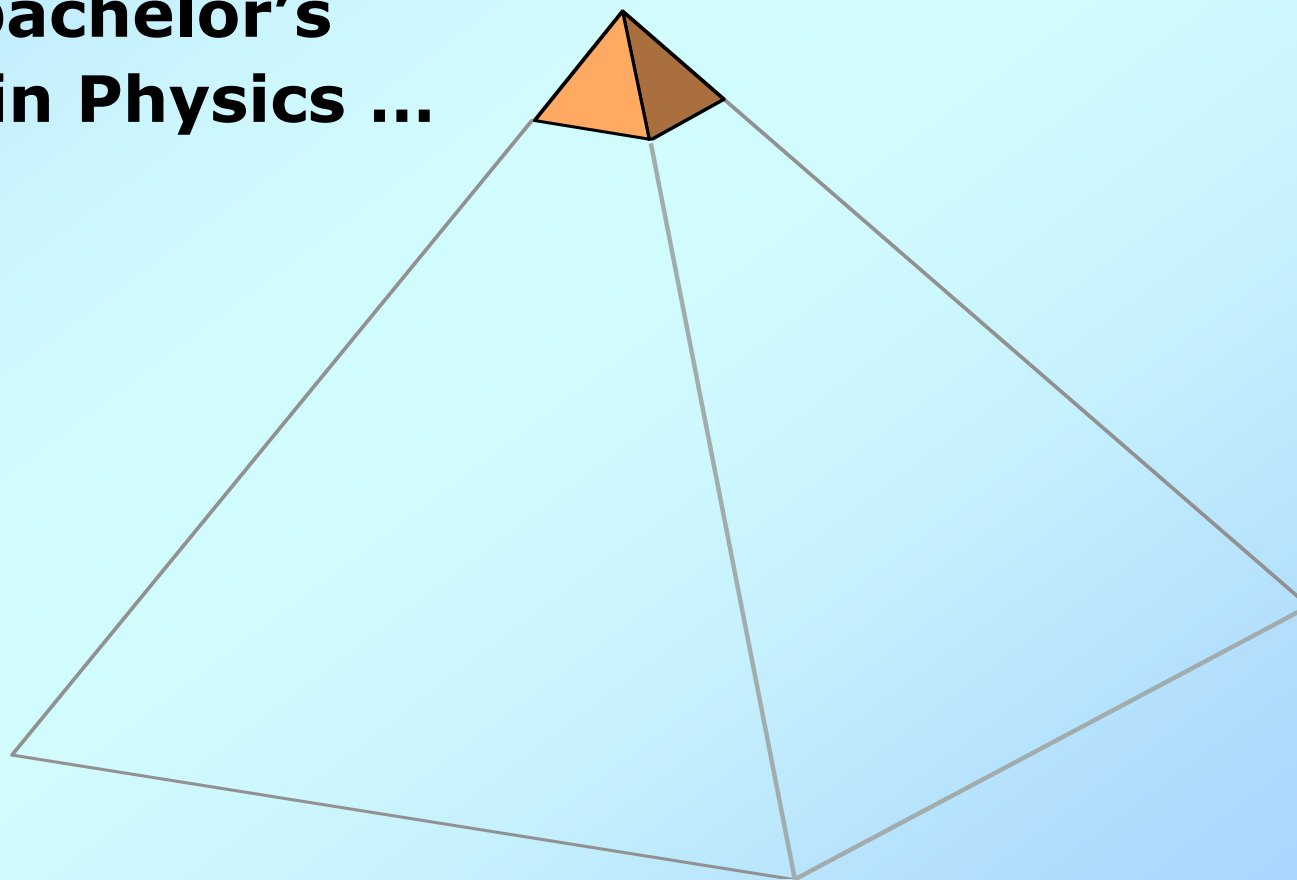
- ▶ **About 1% of these  
get a bachelor's  
degree in Physics**



***AIP Report R-151.33 (1997)***

# ***Problem***

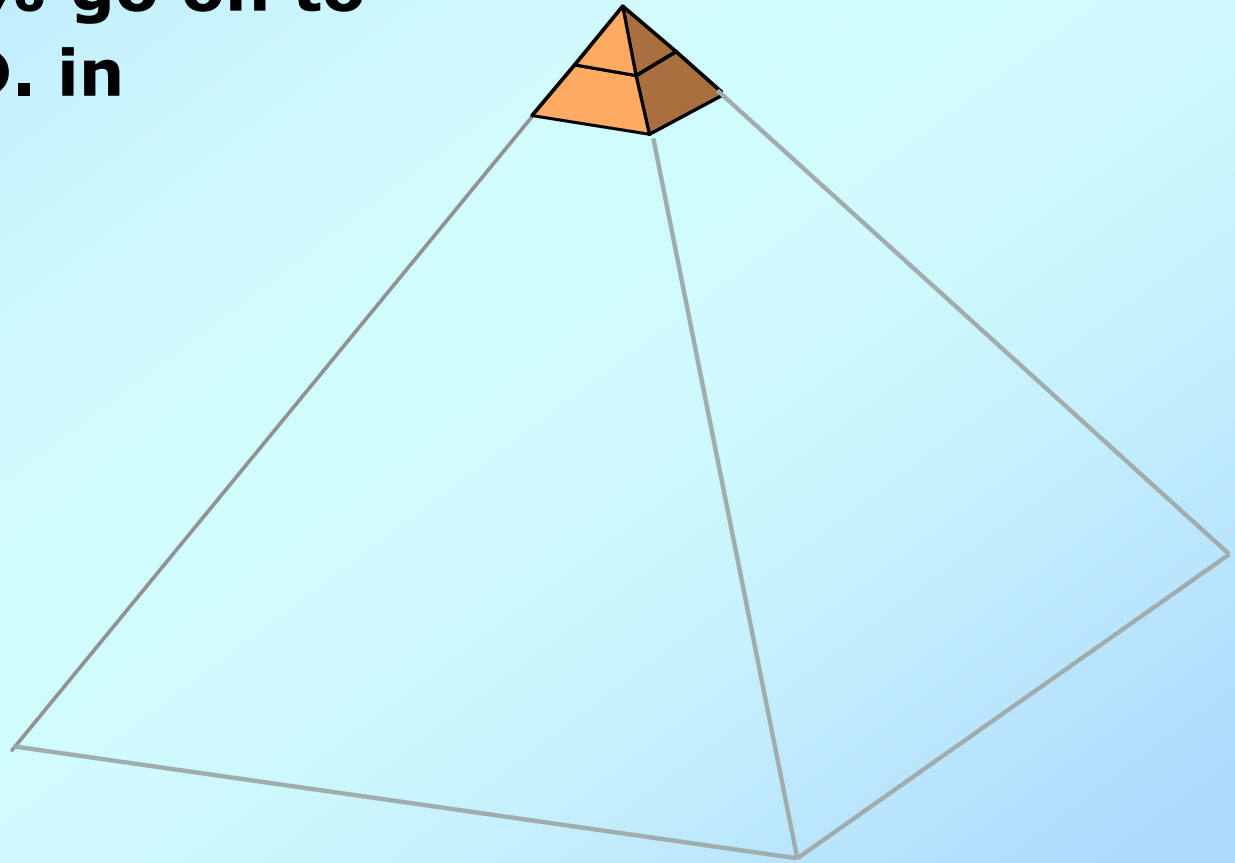
- ▶ **Of the 4300 students  
with a bachelor's  
degree in Physics ...**



***AIP Report R-151.33 (1997)***

# ***Problem***

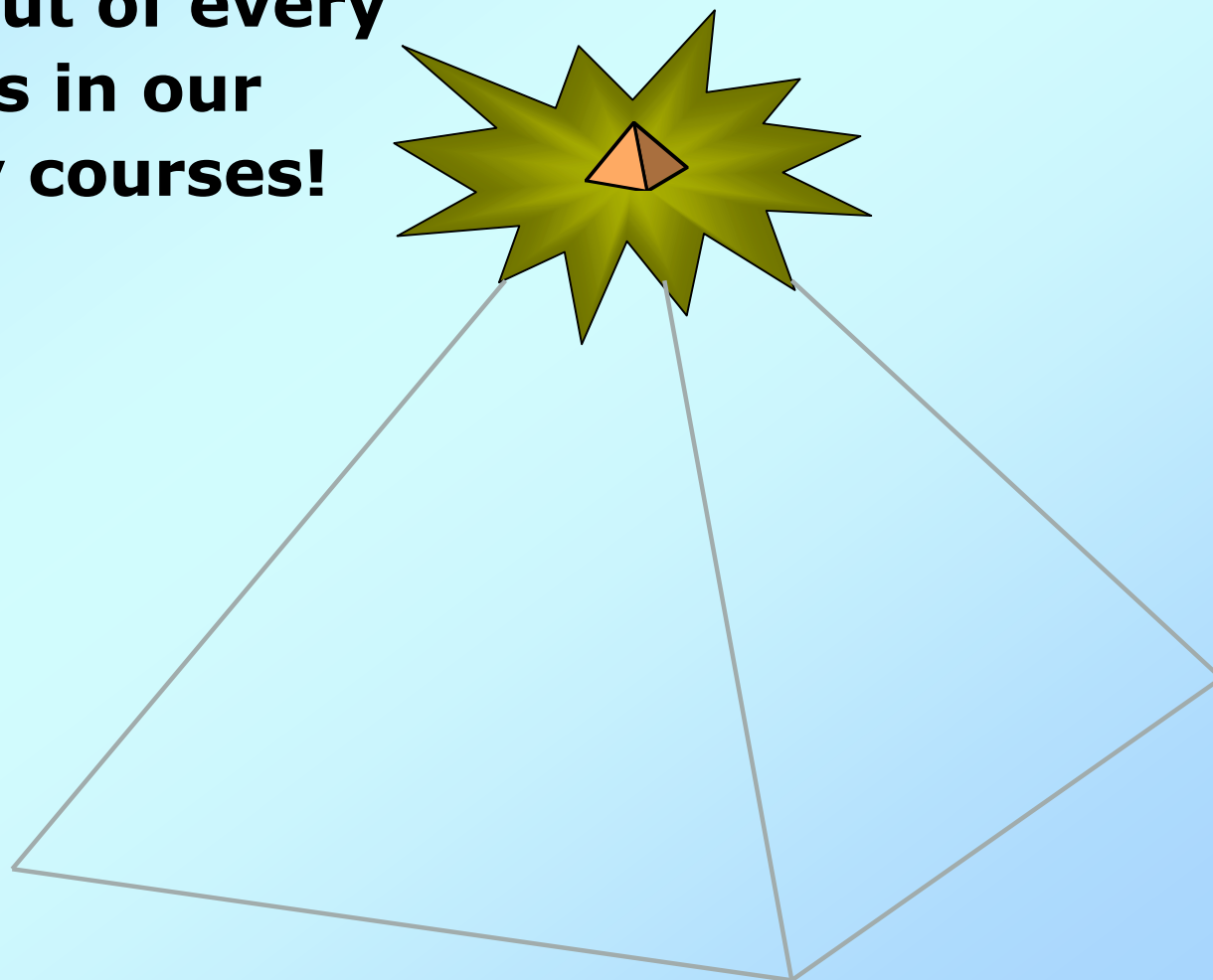
- ▶ **About 35% go on to get a Ph.D. in physics...**



***AIP Report R-151.33 (1997)***

# ***Problem***

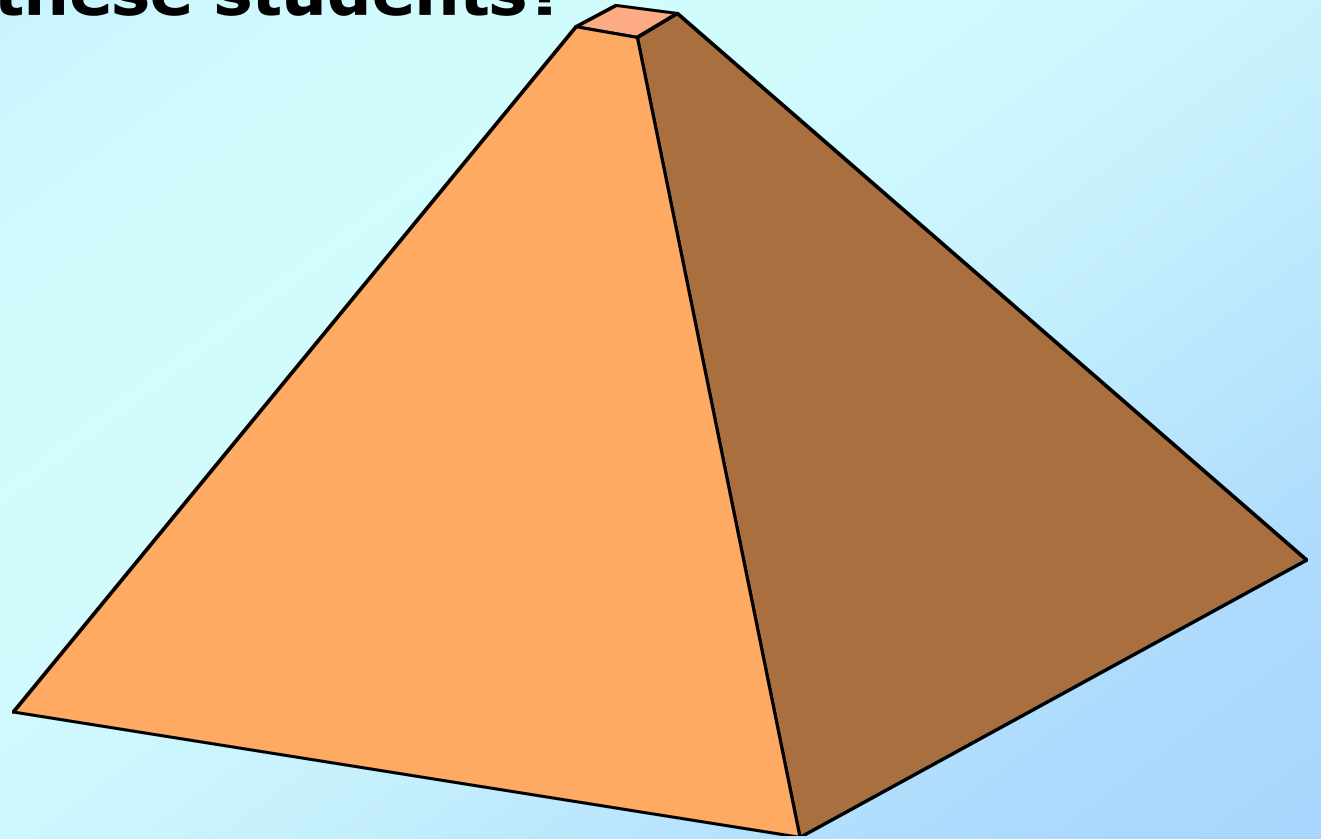
- ▶ **That's one out of every 260 students in our introductory courses!**



***AIP Report R-151.33 (1997)***

# ***Problem***

- ▶ **What about the other 259...?**
- ▶ **Who are these students?**





# ***Problem***

## ▶ **Some disturbing symptoms:**

- Frustration
- Lack of basic knowledge
- Lack of understanding

# ***Problem***



# ***Problem***

## ► **Students know some jargon:**

- “circular motion”
- “barometric pressure”
- “something to the power times ten to the something”

## ► **They know they don't really understand:**

- “I graduated from college but didn't study astronomy”
- “Its been a while since I had physics...”

## ► **But the most worrying thing is:**

- They don't care!

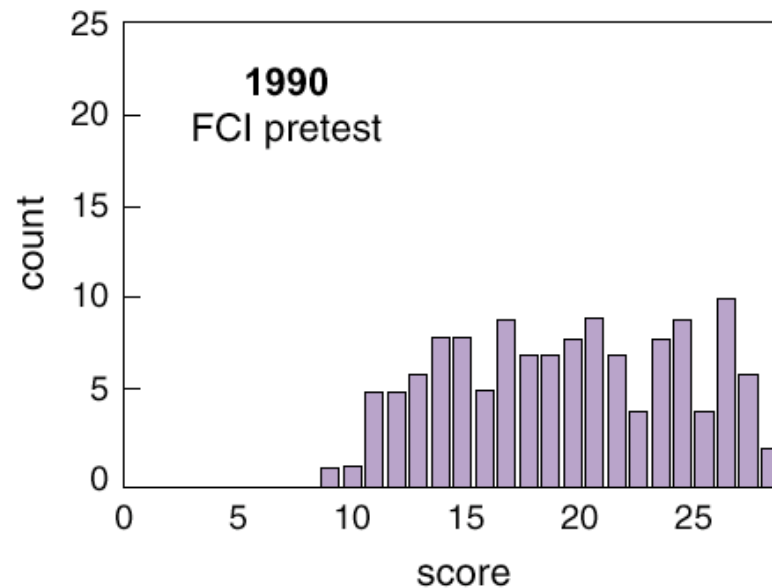
# ***Problem***

**Should we be worried?**



# Problem

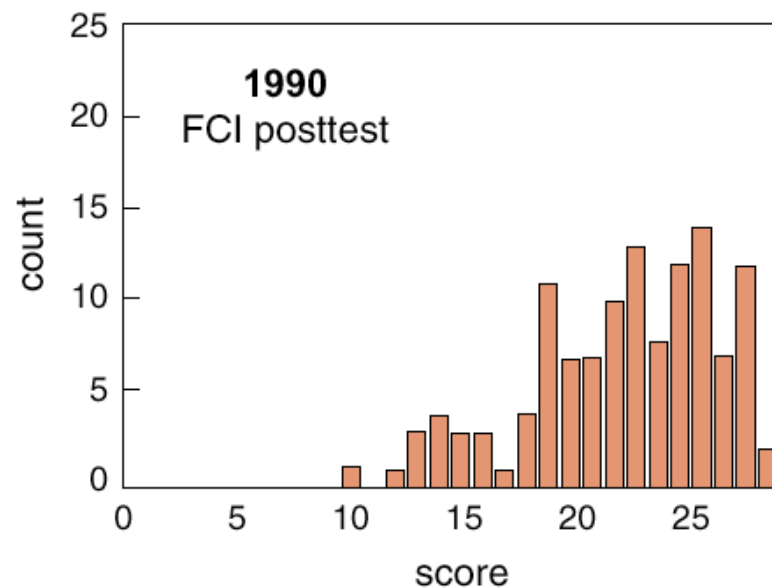
## ► Results of standardized test focusing on concepts rather than problems



Ref: D. Hestenes *et al.* 1992. *The Phys. Teach.* 30: 141-158.

# ***Problem***

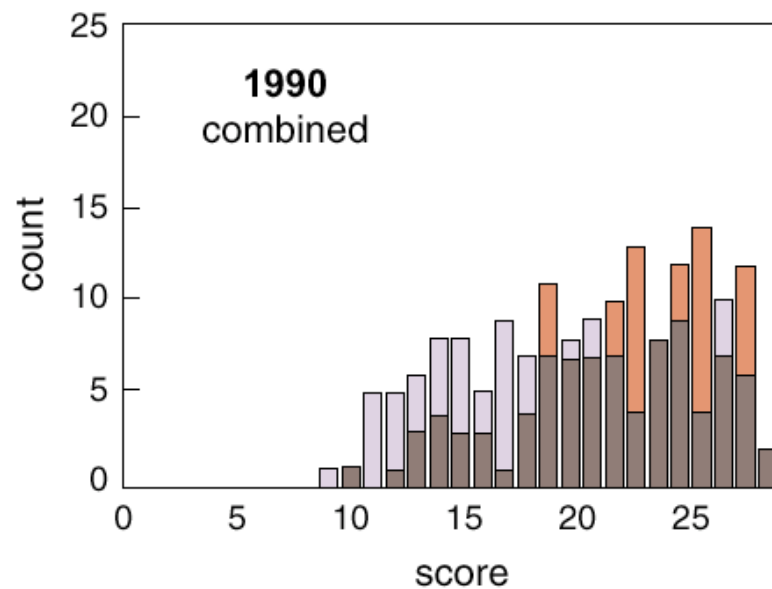
## ► **Results of standardized test focusing on concepts rather than problems**



D. Hestenes *et al.* 1992. *The Phys. Teach.* 30: 141-158.

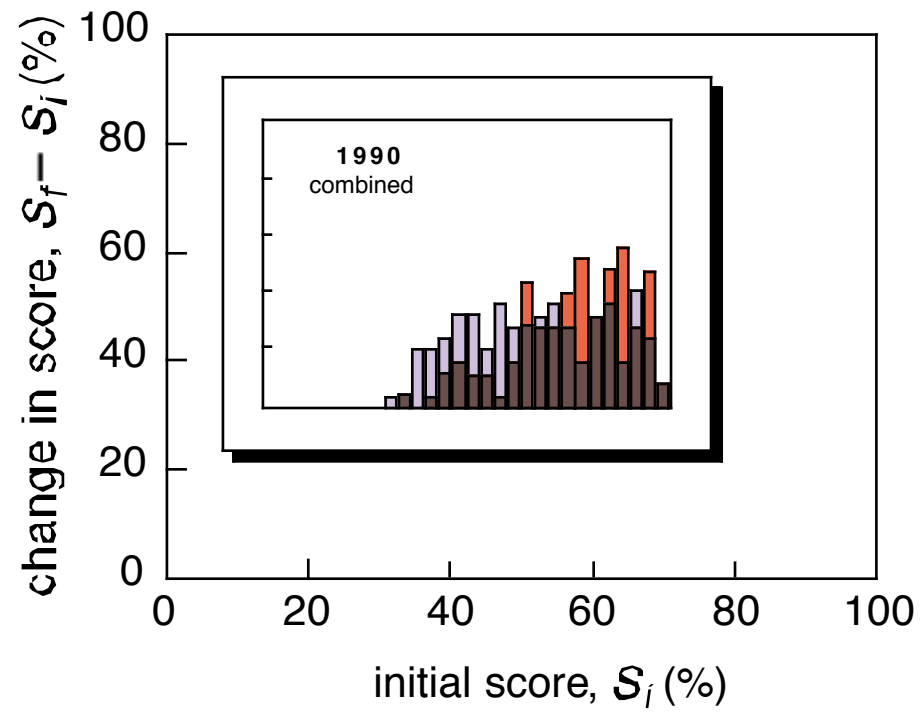
# Problem

## ► Results of standardized test focusing on concepts rather than problems



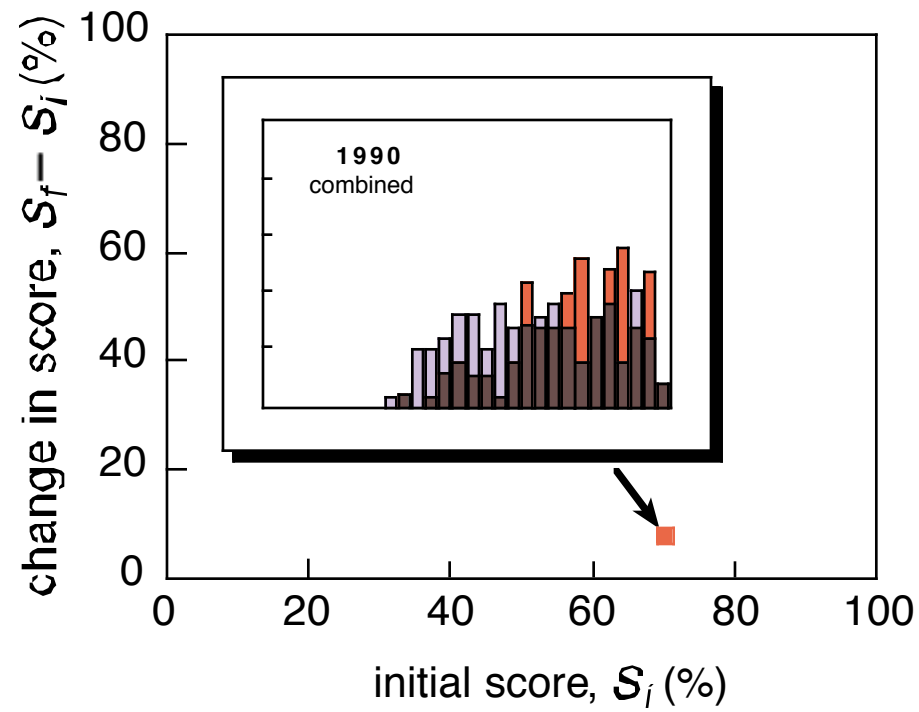
D. Hestenes *et al.* 1992. *The Phys. Teach.* 30: 141-158.

# *Problem*

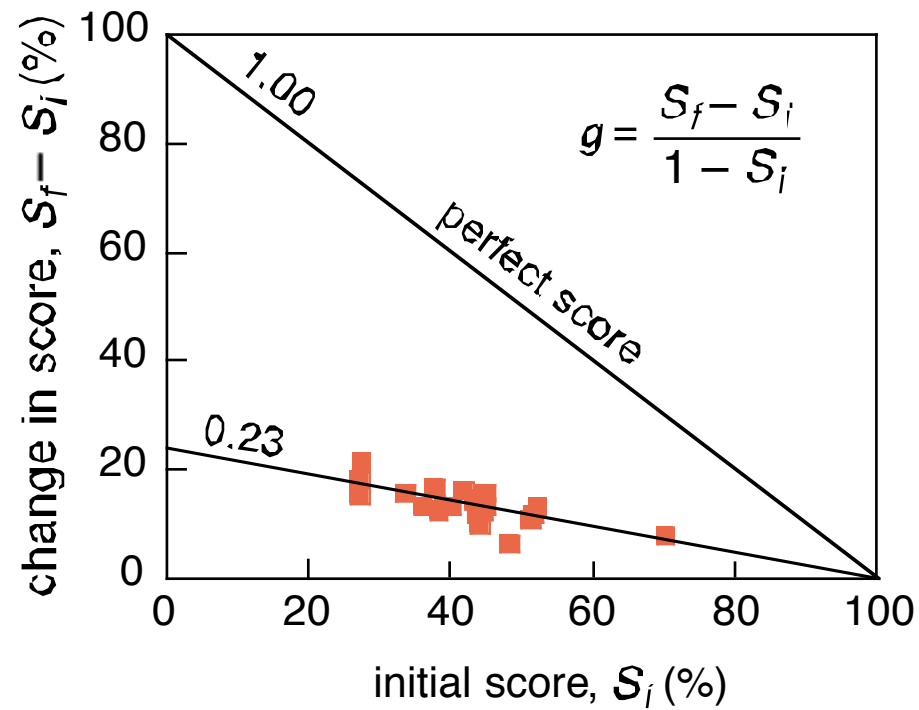




# Problem

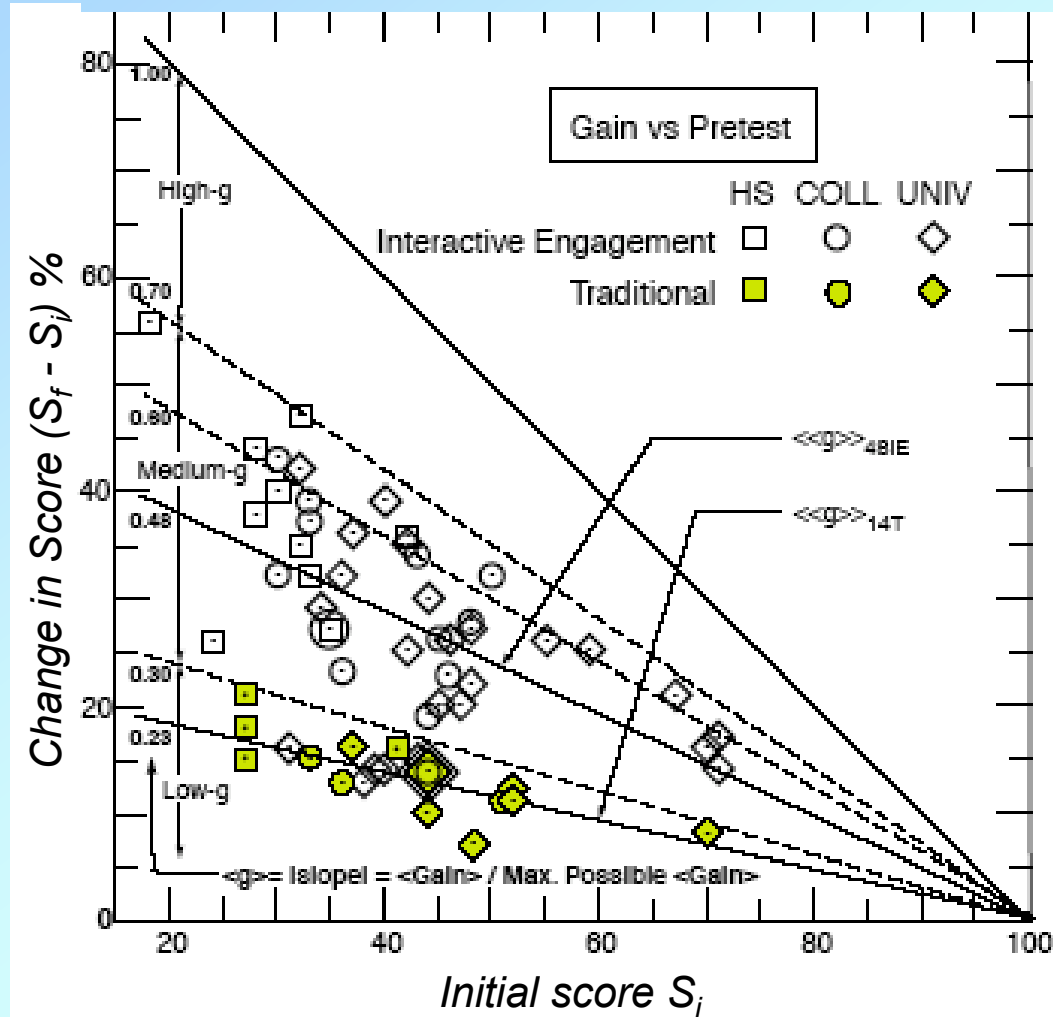


# Problem



R.R. Hake, *Am. J. Phys.* 66, 64- 74 (1998)

# What should we do?



62 courses -- 6542 students

■ -- traditional (14) courses;  
2084 students

□ -- “interactive” (48)  
courses; 4458 students

$$\langle\langle g \rangle\rangle_T = 0.23 \pm 0.04 (\square)$$

$$\langle\langle g \rangle\rangle_{IE} = 0.48 \pm 0.14 (\square)$$

$$\langle g \rangle = (S_f - S_i) / (100 - S_i)$$

$\langle\langle g \rangle\rangle = \text{ave. of averages}$

R.R. Hake, *Am. J. Phys.* 66, 64- 74 (1998)

# ***What should we do?***

## ▶ **Two approaches:**

- Hands on Physics
  - Interactive experiments
  - Computer animations
  - Small group activities
- “Socratic methods”
  - Peer Instruction
  - Increased student / teacher interactions

## ▶ **Basic necessity**

- Information transfer done outside of classroom

# *Hands on methods*



MIT TEAL room

Capacity: ~ 100 students

Cost: ~  $\$1.5 \times 10^6$



John Belcher, MIT

<http://www.swiss.ai.mit.edu/projects/icampus/projects/teal.html>

# ***What should we do?***

## **Peer Instruction at Harvard:**

- ▶ **Low impact - low cost**
- ▶ **Demonstrated results**
- ▶ **Core elements**
  - Information transfer outside of class
  - Classroom focused on student confusion
  - Instructor acts as a facilitator
  - Students learn through peer discussions

# ***Peer Instruction***

## ▶ **After discussing a significant concept:**

- Stop; ask ConcepTest question
- Steps:
  1. Question
  2. Thinking
  3. Individual answer
  4. Peer discussion
  5. Individual answer
  6. Instructor explanation

## ▶ **Adjust lecture based on feedback**

## *ConceptTest*

**A boat carrying a large boulder is floating in a lake. The boulder is thrown overboard and sinks to the bottom of the lake. Does the level of the water in the lake (with respect to the shore):**

1. go up
2. go down, or
3. stay the same?



## *ConcepTest*

**Most of the mass accumulated by a tree to go from a seed to a fully grown tree comes from:**

1. Nutrients in the soil
2. Water
3. Air
4. None of the above

## ***How can technology help?***

### ▶ **Information collection**

Collect student responses in classroom and outside

### ▶ **Information distribution**

Deliver materials and information to students

### ▶ **Information presentation**

Discover connections between all the different pieces of information that go with a course

## ***Steps in teaching a PI class***

- 1. Prepare students**
- 2. Review student confusion before class**
- 3. Initiate discussions in class**
- 4. Use feedback from student responses to moderate progress in class**
- 5. After class use feedback to assign reading material for the next class**

# Reading assignments in ILT

[Readings](#) > Current Reading

**Due:** 6/29/2003 at 11:59 PM

**Status:** Not completed

1. Suppose that objects A and B are electrically charged and are observed to attract each other. Both A and B are observed to attract a third object C. Is it true or false that these observations, if correct, would imply the existence of three different kinds of charge? Explain your reasoning.

**Answer:**

2. Consider three charged particles carrying nonzero charges  $q_1$ ,  $q_2$ , and  $q_3$ . The vector sum of the forces exerted by 1 and by 2 on 3 is zero. Is it true that (a) 3 must necessarily lie somewhere along the line connecting 1 and 2 or (b) 3 must lie somewhere along that line, but only between 1 and 2?

**Answer:**

3. Please tell us briefly what **single** point of the reading you found most difficult or confusing. If you did not find any part of it difficult or confusing, please tell us what parts you found most interesting.

**Answer:**

- **Students can answer the assignment when it is available to them**

# Reading assignments in ILT

The screenshot shows a web browser window titled "Galileo: Students" with the URL <http://www.deas.harvard.edu/galileo/reading/assignments/specificassign>. The browser's address bar also contains a Google search bar. Below the browser window, a list of student responses is displayed. Each entry includes a student's name, a small profile picture, a link to their response, and the date and time of the response. The students listed are Kay Downer, Maria Marzilli, Eleanor Adams, Gita Rao, and paul mathieu. Each student's response is a paragraph of text discussing electrostatic force and Coulomb's law. The interface also includes links for "NOTEBOOK", "ALL ANSWERS", and "Create CT" for each student. At the bottom, a pagination bar shows "1 - 10 of 87 Responses" with navigation buttons.

Student Name	Response Text	Grade	Responded At
Kay Downer	Student Response: The solution to "Electrostatic tug of war" (pg 23) is unclear. I don't really understand what the part (b) solution is saying - is it just saying that when the particles are arranged so that the vector sum on 1 is zero, then the vector sum on 2 and on 3 is NOT zero? Or is there more to it than that?	2	2/3/2002 at 4:23 pm
Maria Marzilli	Student Response: The single point of the reading I found most difficult were the sections about the resolution of electrostatic force into vectors and summing up various vectors to find the net electrostatic force on an object being attracted or repelled by various charge carriers.	2	2/4/2002 at 12:24 am
Eleanor Adams	Student Response: Determining the vectors of electrostatic force when there are multiple charged particles.	2	2/4/2002 at 12:28 am
Gita Rao	Student Response: The question 2 on this identified my confusion. I'm not sure if I understand the patterns necessary for particles to be in electrostatic equilibrium.	2	2/4/2002 at 1:04 am
paul mathieu	Student Response: section 26.6 and 26.7 coulomb's law, what is the subscript under the F? (i.e eq 26.1)	2	2/4/2002 at 1:39 am


► **Students' work, face and names are all connected**

# Reading assignments in ILT

<http://qemp.de>  
Apple ▾ Visualizat  
**READING**

ALL ANSWERS | Create CT

Please tell us briefly what single point of the reading you found most difficult or confusing. If you did not find any part of it difficult or confusing, please tell us what parts you found most interesting.



From: Emilia Asare <easare@fas.harvard.edu> (responded)  
Received: Fri, 21 Feb 2003 18:09:34 -0500

I am confused about part b of Checkpoint 29.6 I don't really understand why there is no electrostatic force between C and B. After further reading, I figured that this is probably an equipotential line, but I don't really understand how we would know that from the diagram.

RESPONSE

Please tell us briefly what single point of the reading you found most difficult or confusing. If you did not find any part of it difficult or confusing, please tell us what parts you found most interesting.


To: Emilia Asare <easare@fas.harvard.edu>

Subject:

Dear Emilia,


Student

Ans

Ale  
Kin  
on  
kin  
pot


Ans

and

Em  
unc  
rea  
unc


Has

poi

Kor  
in t

Me

the  
fiel

Me  
the  
fiel

Hope this helps,

Eric Mazur

Send without saving to FAQ

FAQ

Reduce original response to simple question:

I am confused about part b of Checkpoint 29.6 I don't really understand why there is no electrostatic force between C and B. After further reading, I figured that this is probably an equipotential line, but I don't really understand how we would know that from the diagram.

Index question: (e.g., Section 10.2, Checkpoint 6.7)

☐ Hide from students

☐ Global

Send & save to FAQ

Edit or copy over FAQ response:

- ← (CT in class to address point) Reading assignment
- ← (Lack of specifics) Reading assignment
- ← (Referring to question) Reading assignment
- ← (Section 29.1) work-energy diagrams
- ← (Section 29.2) work in nonuniform field
- ← (Section 29.2) potential and sign of charge



# Peer Instruction in ILT

Yahoo! News ▾ ILT ▾ DEAS ▾ Apple ▾

VU Course

Logged in as Suvendra Dutta  
Sign out

HOME READING LECTURES ASSIGNMENTS FORUMS NEWS HANDOUTS

Courses > VU Course > Introduction > Add CT

Please select the CTs you want to add to your lecture and click "Add to lecture". You can also click "Generate slides" to produce slides of question selected. You can modify your search or perform a new search using the search tools on the left. You can change the view of the CTs using the "Expand all" or "Collapse all" links on the left.

1 - 10 of 156 CTs > > Sort by: Question text Sort

1. Consider two identical resistors wired in series. If there is an electric current through the combi...  
1. equal to  
2. half  
3. smaller than, but not necessarily half

2. A  $\text{CuSO}_4$  solution is placed in a container housing coaxial cylindrical copper electrodes...  
1. positive,  
2. negative,  
3. both positive and negative.

3. A battery establishes a steady current around the circuit below. A compass needle is placed successi...  
1. P, Q, R,  
2. Q, R, P,  
3. R, Q, P,

© 2002 Eric Mazur  
All rights reserved  
Report a problem

Yahoo! News ▾ ILT ▾ DEAS ▾ Apple ▾

VU Course

Logged in as Suvendra Dutta  
Sign out

HOME READING LECTURES ASSIGNMENTS FORUMS NEWS HANDOUTS

Courses > VU Course > Introduction 2/4 > Create ConceptTest

Add a new ConceptTest

Introductory text of your question.

Text to appear after image.

1 Multiple choice no. 1  
2 Multiple choice no. 2

1 More choices

Text to appear after answer choices.

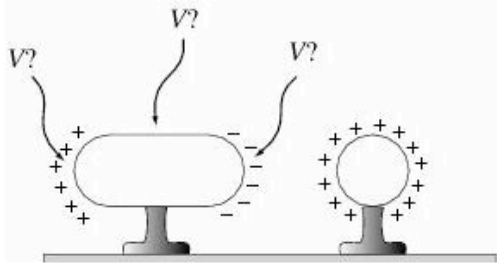
Explanation of answer.

© 2002 Eric Mazur  
All rights reserved  
Report a problem

- Pull in ConceptTest questions from a database
- Create new ones yourself and add to the database

# Peer Instruction in ILT

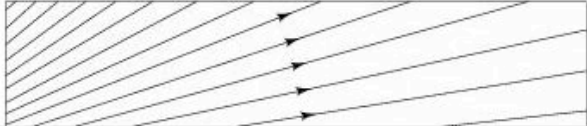
1. A charged object is brought near an uncharged metal object. Negative charges accumulate on the side of the uncharged object nearest to the charged sphere, positive charges on the opposite side. On the uncharged metal object, the potential is



1. largest on the positive side  
2. largest on the negative side  
3. largest in the middle  
4. the same everywhere

Answer

2. A cylindrical piece of insulating material is placed in an external electric field, as shown. The net electric flux passing through the surface of the cylinder is



Internet zone

- ▶ Student view of lecture automatically created
- ▶ And published to students when specified



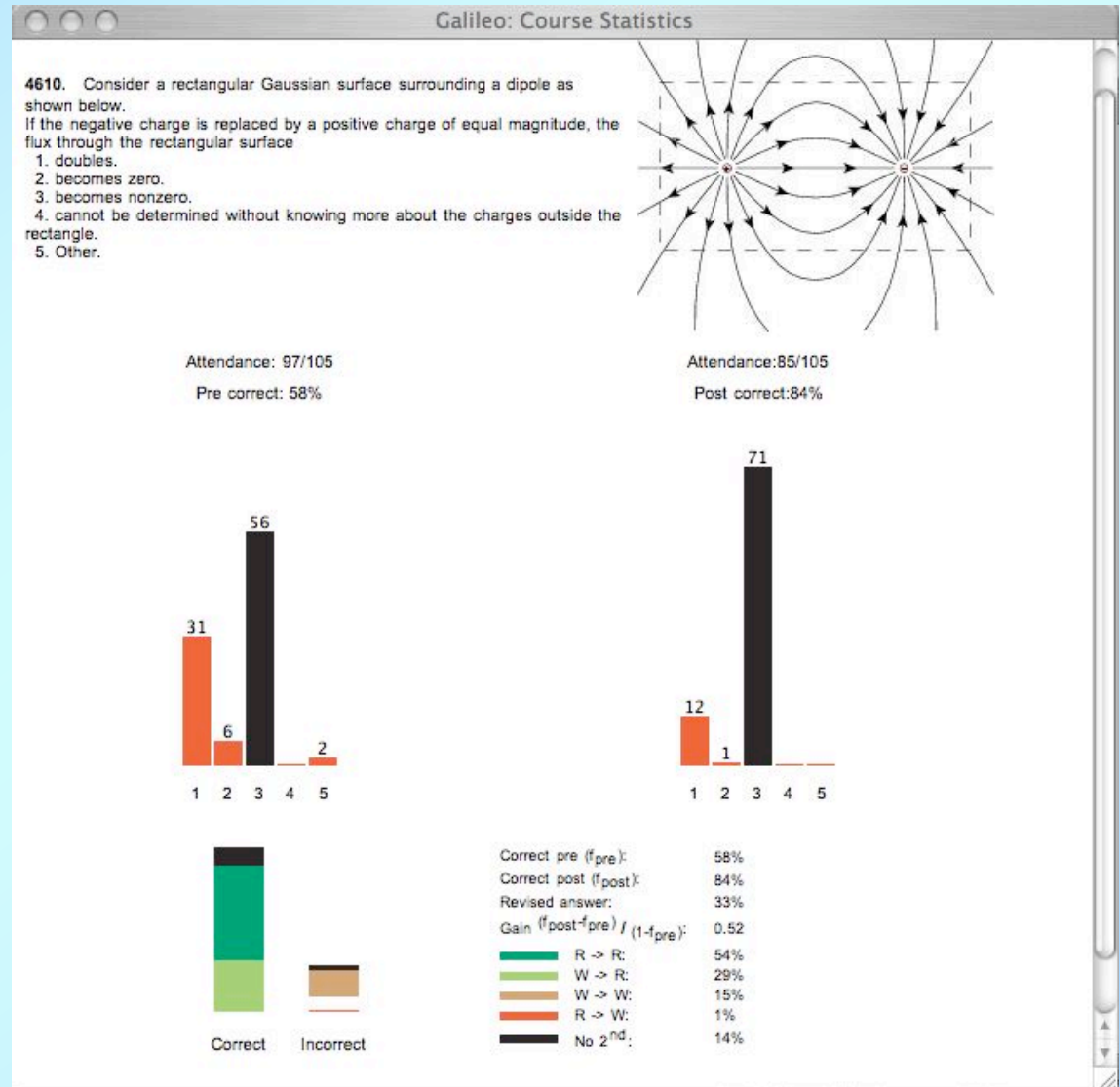
## ***Peer Instruction in ILT***



- **In class students follow the PI process**
- **Technology is useful in collecting data**
- **Easy to do simple analysis**
- **But Severe limitations:**
  - a) Restricted to multiple choice
  - b) No location information on students
  - c) One way communication
  - d) Data is volatile, not linked to rest of the course

# Peer Instruction in ILT

- Upload PRS session files
- Automatically grade students for participation
- Grade questions for effectiveness



# Face book

Milo Artiga I thought Lenz' law was the most interesting part since it is a priori, but the at such a simple e

Mark Riddell Ex changes direct greater detail/c produce electric

Javier Valle I do charge separat there must be a have to thus ex confused!

Lisa Simpson! Ha get the director all the figures in because there is 33.3, why does increases when the magnetic fi toward R? And eddy currents v

William Olson I about the effect figure out what types of things can confound

**Lisa Simpson**  
F11112222  
[lsimpson@fas.harvard.edu](mailto:lsimpson@fas.harvard.edu)

Laboratory 8 Tue 1:00:pm  
Section 5 Wed 4:00:pm

Class: 2004  
Major: economics  
Registered on: 2/2/2003  
PRS Unit ID: 0248  
Final grade: B

Forums: 4 posts  
Email: 36  
No. of self-tests: 1 self-tests  
Reading FAQs: 1

RA	CT	PT	L	PS	HE	OT	FE
6/6	1/1	2/2	9/10	40/40	20/35	5/5	39/60
4/6	5/6	2/2	9/10	28/35	14/35	15/15	
5/6 *	5/6	0/2		35/35	25/35	18/18	
5/6 *	2/3	2/2	9/10	35/35*			
5/6 *	6/9	2/2	10/10	35/35			
5/6	7/8	0/2		35/35			
6/6	3/4	2/2		35/35			
6/6	5/9	2/2		35/35			
5/6 *	9/9	2/2					
6/6	8/11						
6/6							
5/6 *	5/5						
6/6	10/10						
6/6	8/9						
6/6	10/10						
6/6	7/7						
6/6							
6/6	11/11						
6/6	9/9						
6/6	8/8						
6/6	13/13						
6/6							
119/126	132/148	14/18	37/40	278/285	59/105	38/38	39/60
94%	89%	78%	93%	98%	56%	100%	65%

RA: Reading assignments; CT: ConcepTests; PT: Pretest; L: Laboratory; PS: Problem Set; HE: Hour Exam; OT: Online Test; FE: Final Exam;

- **By connecting every element of the course together with the student, ILT makes it easier to get to “know” a large class**

## *Summary*

- ▶ **Fundamental problem in classes - concepts not getting across to students**
- ▶ **Small changes in the class can have significant positive effect on students learning**
- ▶ **Technology can help implement pedagogical changes**

# ***Acknowledgments***

## **This work is funded by:**

NSF Distinguished Teaching Scholar Award  
DEAS Information Technology Group

## **For more information please visit:**

<http://mazur-www.harvard.edu>

<http://www.deas.harvard.edu/galileo>

## ***Useful Resources***

- ▶ **Old Project Galileo site (useful information on education research):**
  - ▶ <http://galileo.harvard.edu>
- ▶ **New Galileo site (updated ConcepTests and tools):**
  - ▶ <http://www.deas.harvard.edu/galileo>
- ▶ **JiTT web-site:**
  - ▶ <http://webphysics.iupui.edu/jitt/jitt.html>
- ▶ **Mazur Group papers & talks:**
  - ▶ <http://mazur-www.harvard.edu/library>
- ▶ **Prof. Mazur's Spring Physics course web-site:**
  - ▶ <http://physics1.harvard.edu>
- ▶ **Suvendra Nath Dutta contact info:**
  - ▶ Email: [sdutta@deas.harvard.edu](mailto:sdutta@deas.harvard.edu)
  - ▶ Phone: (617) 495-9616