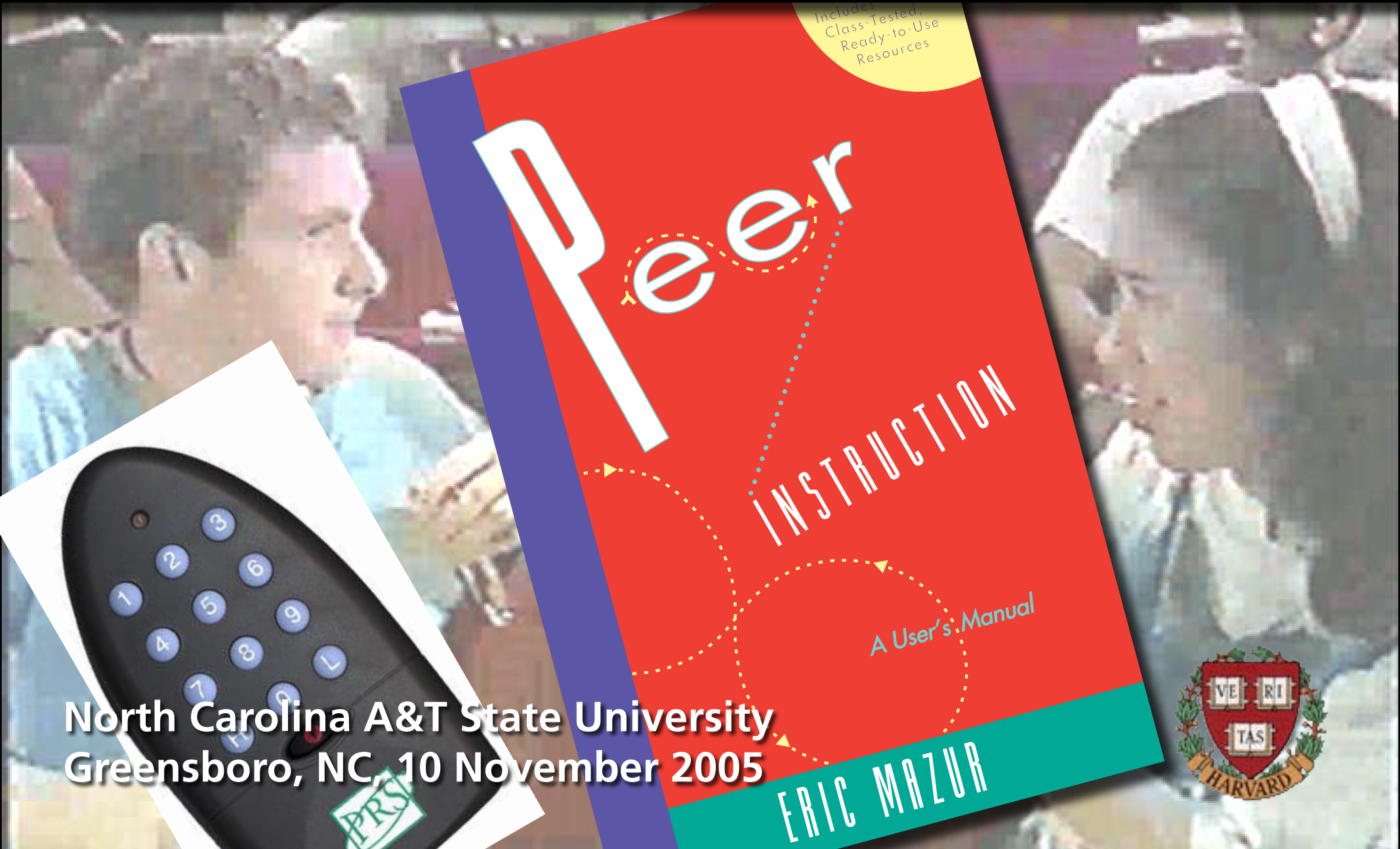
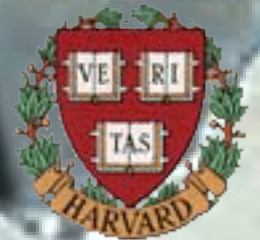


Memorization or understanding: Are we teaching the right thing?



North Carolina A&T State University
Greensboro, NC, 10 November 2005



Outline

- Problem



Outline

- Problem

- Cause



Outline

A photograph of a group of people sitting around a table in a meeting. The image is semi-transparent, with text overlaid on it. The text is arranged in a vertical list on the left side of the image. The background shows several people, including a man in a blue shirt on the left and a woman in a white headscarf on the right, engaged in conversation.

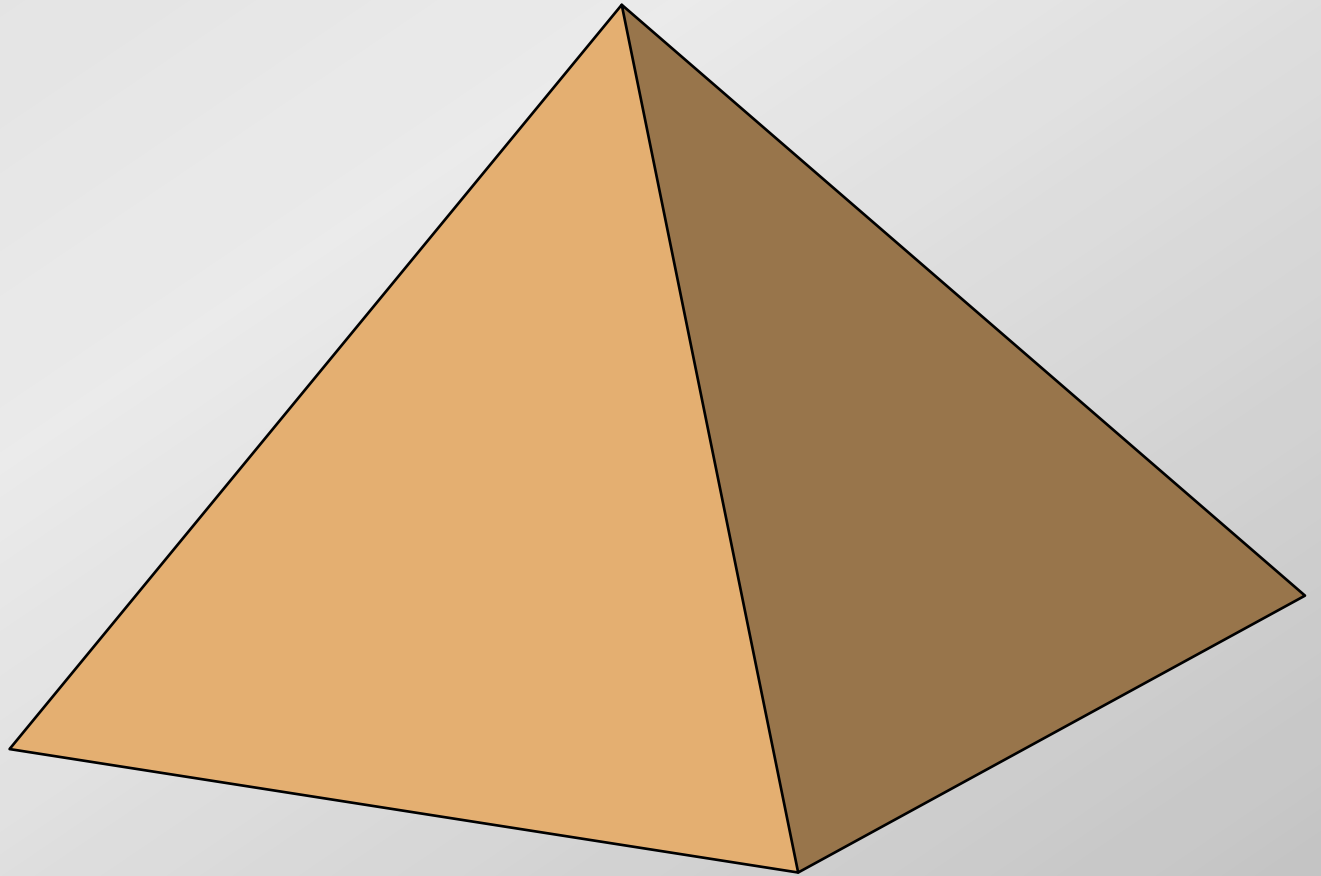
- **Problem**

- **Cause**

- **Remedy**

We have a problem

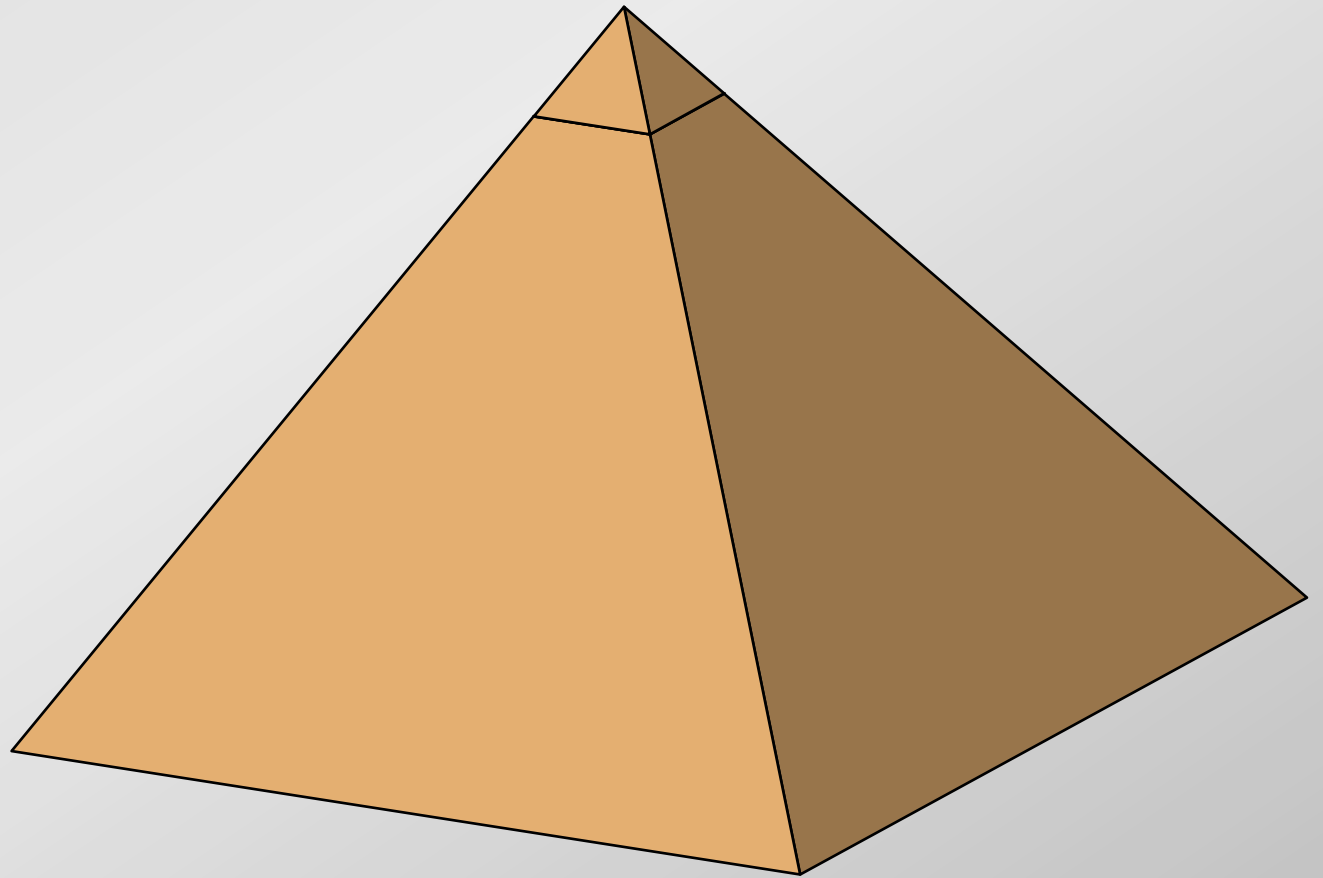
340,000 students take
introductory physics
each year



AIP Report R-151.39 (2003)

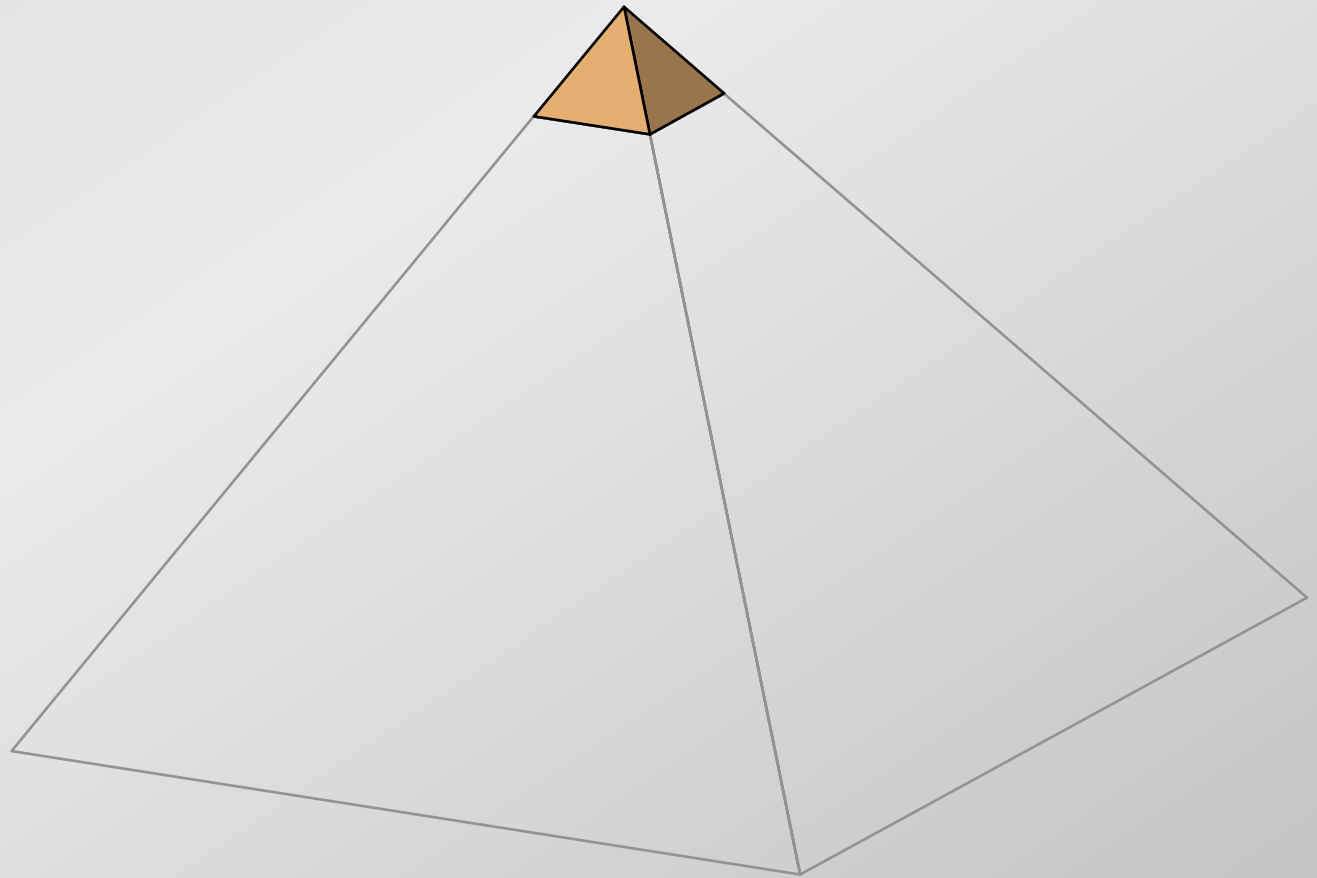
We have a problem

about 1% of these get
a bachelor's degree
in physics



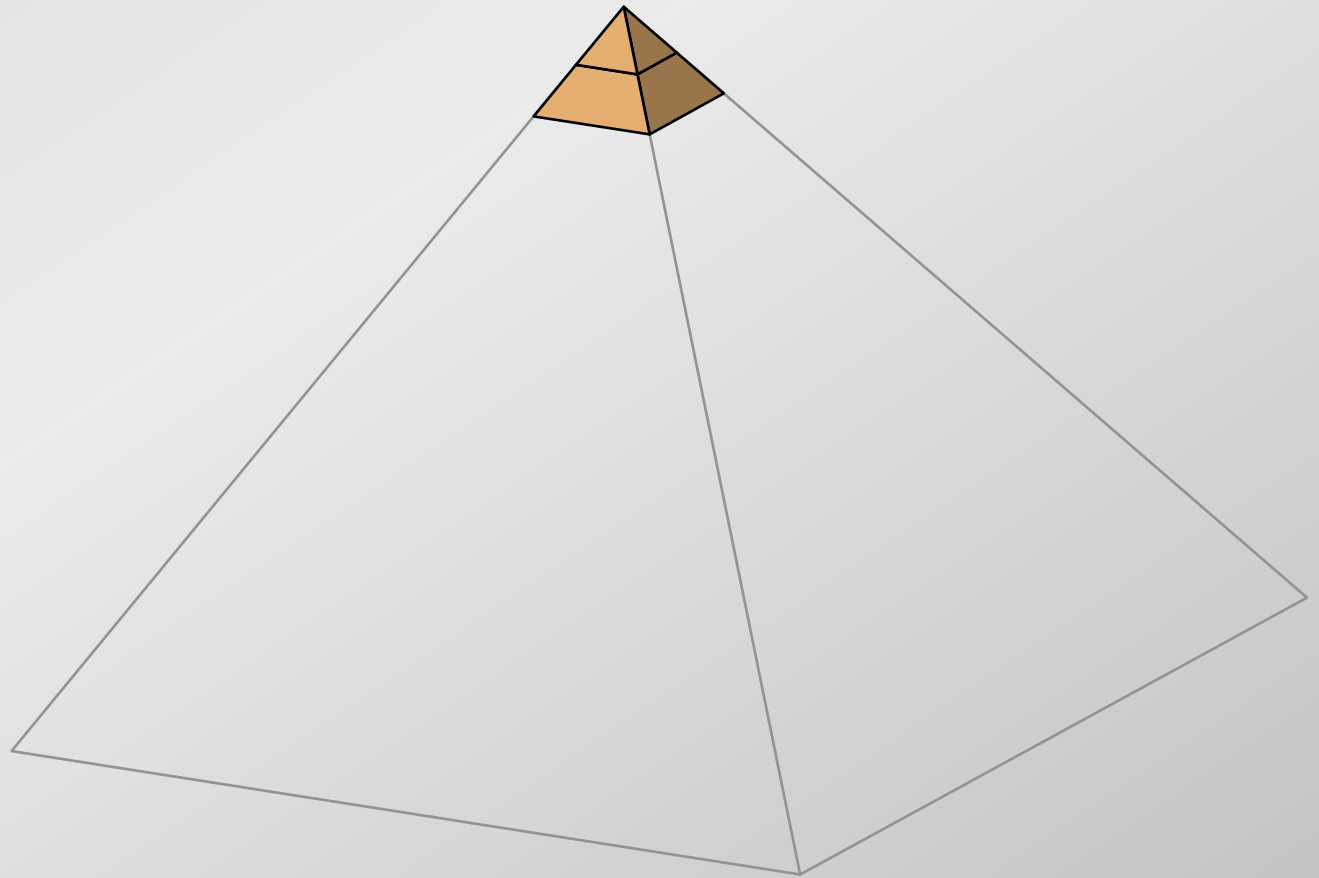
We have a problem

Of the 4,100 students with
a bachelor's degree
in physics...



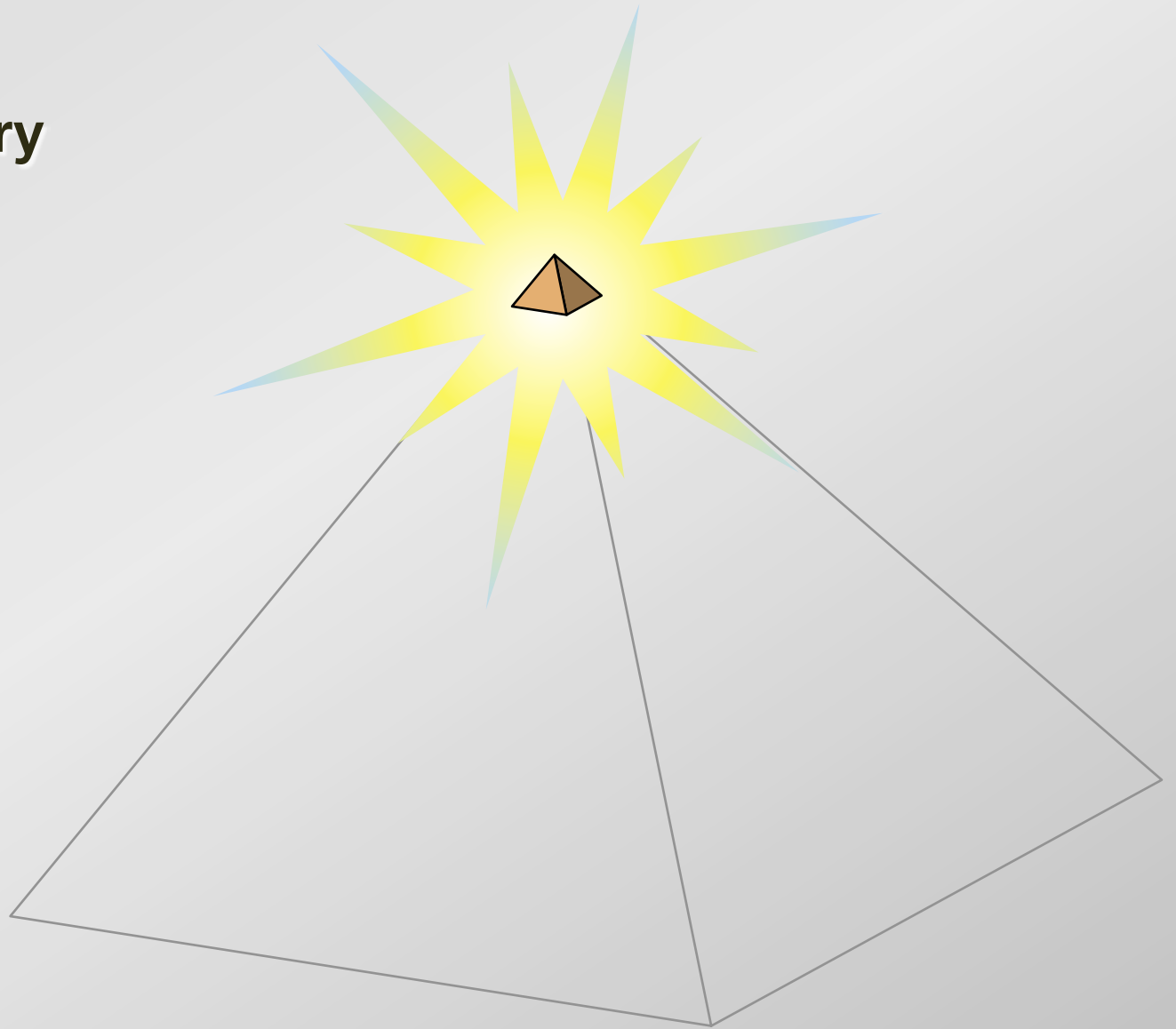
We have a problem

about 28% go on to get a
Ph.D. in physics...



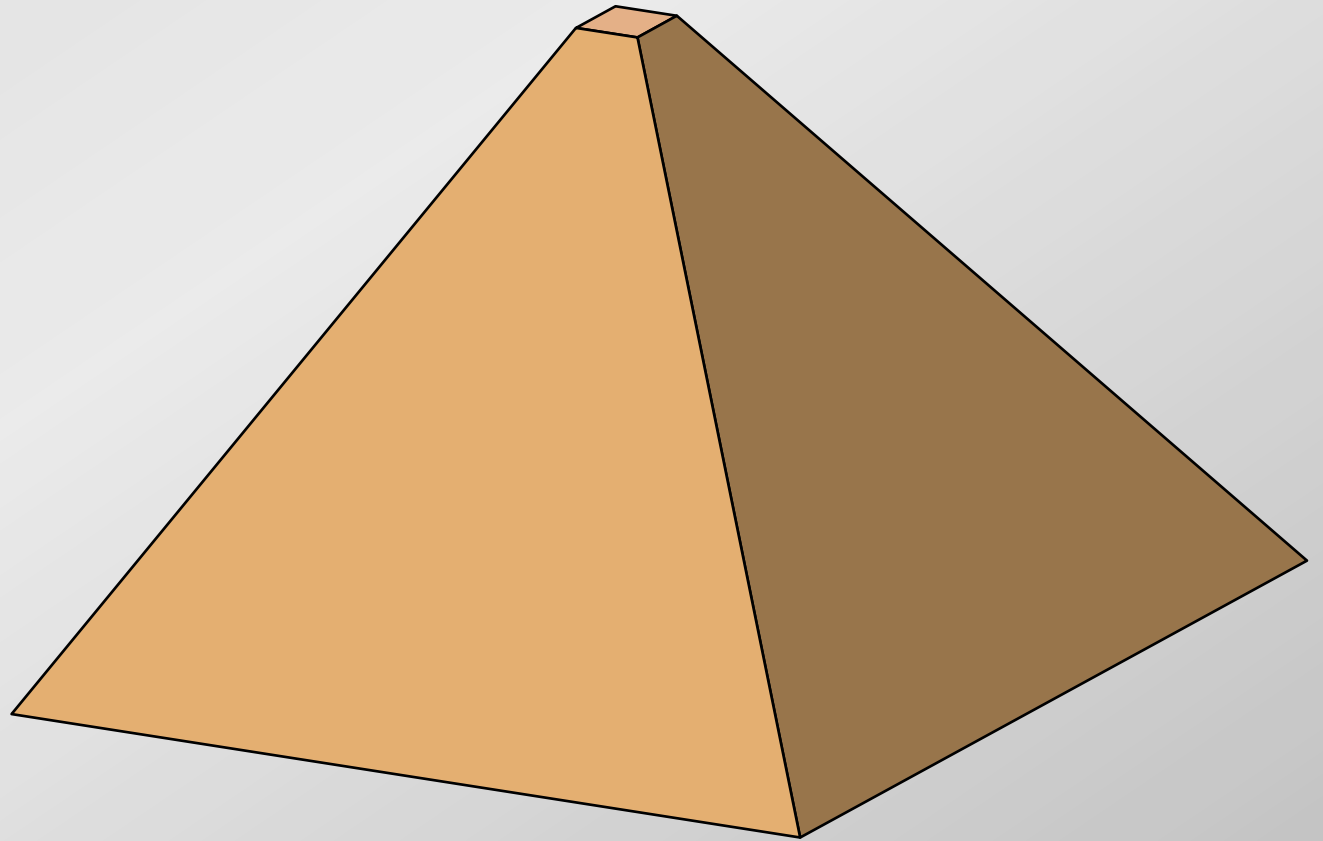
We have a problem

That's one out of every
300 students in our
introductory
courses!



We have a problem

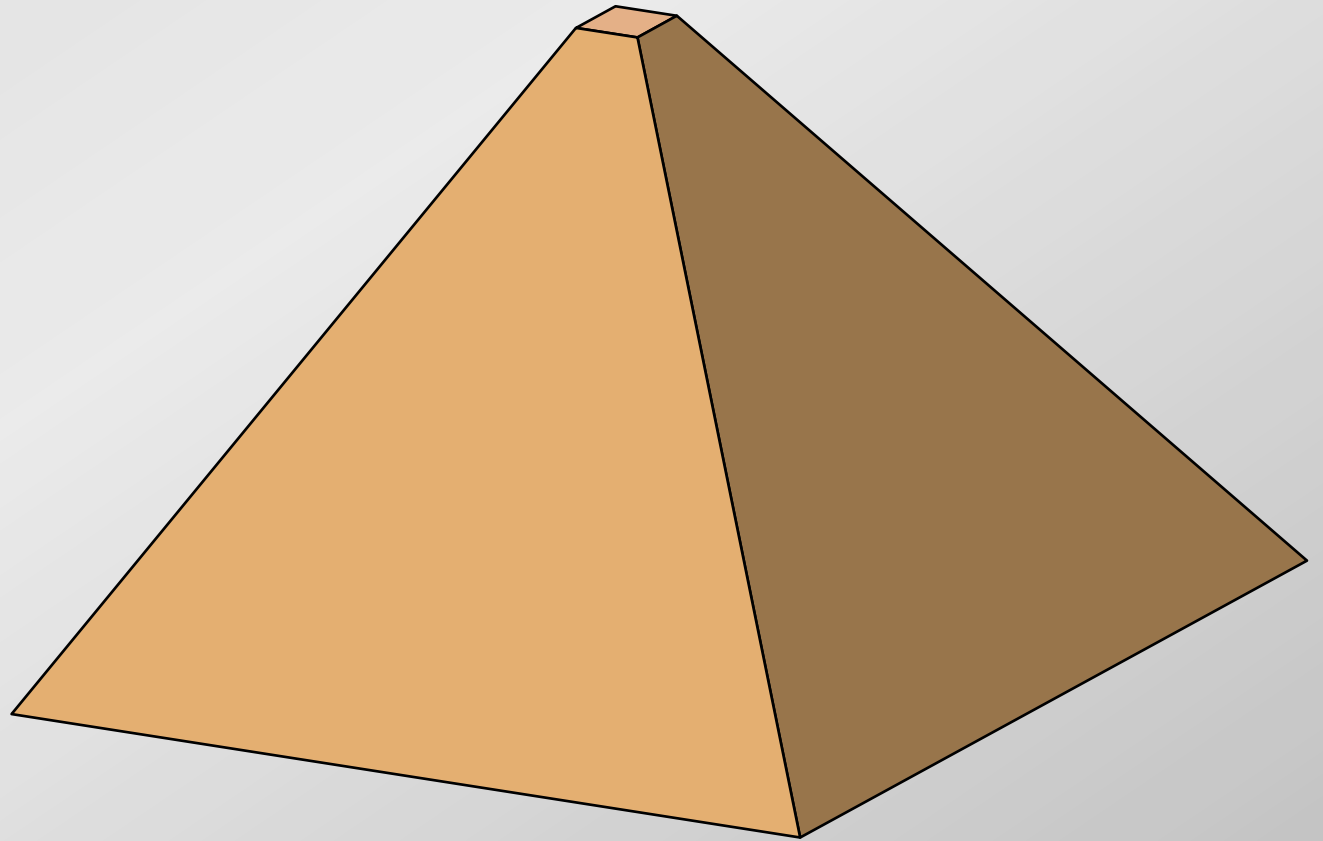
What about the
other 299...?



AIP Report R-151.39 (2003)

We have a problem

What do we know
about these
students?



We have a problem

Some disturbing symptoms:

- **frustration**
- **lack of understanding**
- **lack of basic knowledge**

We have a problem

They know the jargon:

- circular motion
- barometric pressure
- light radius
- something to the power times ten to the something

We have a problem

They are aware of their lack of knowledge:

- I graduated from college, but I didn't study *astronomy*
- It's been a while since I've had physics

We have a problem

They are aware of their lack of knowledge:

- I graduated from college, but I didn't study *astronomy*
- It's been a while since I've had physics

...and they don't care!

We have a problem

Should we worry?

We have a problem

We'd better!

We have a problem

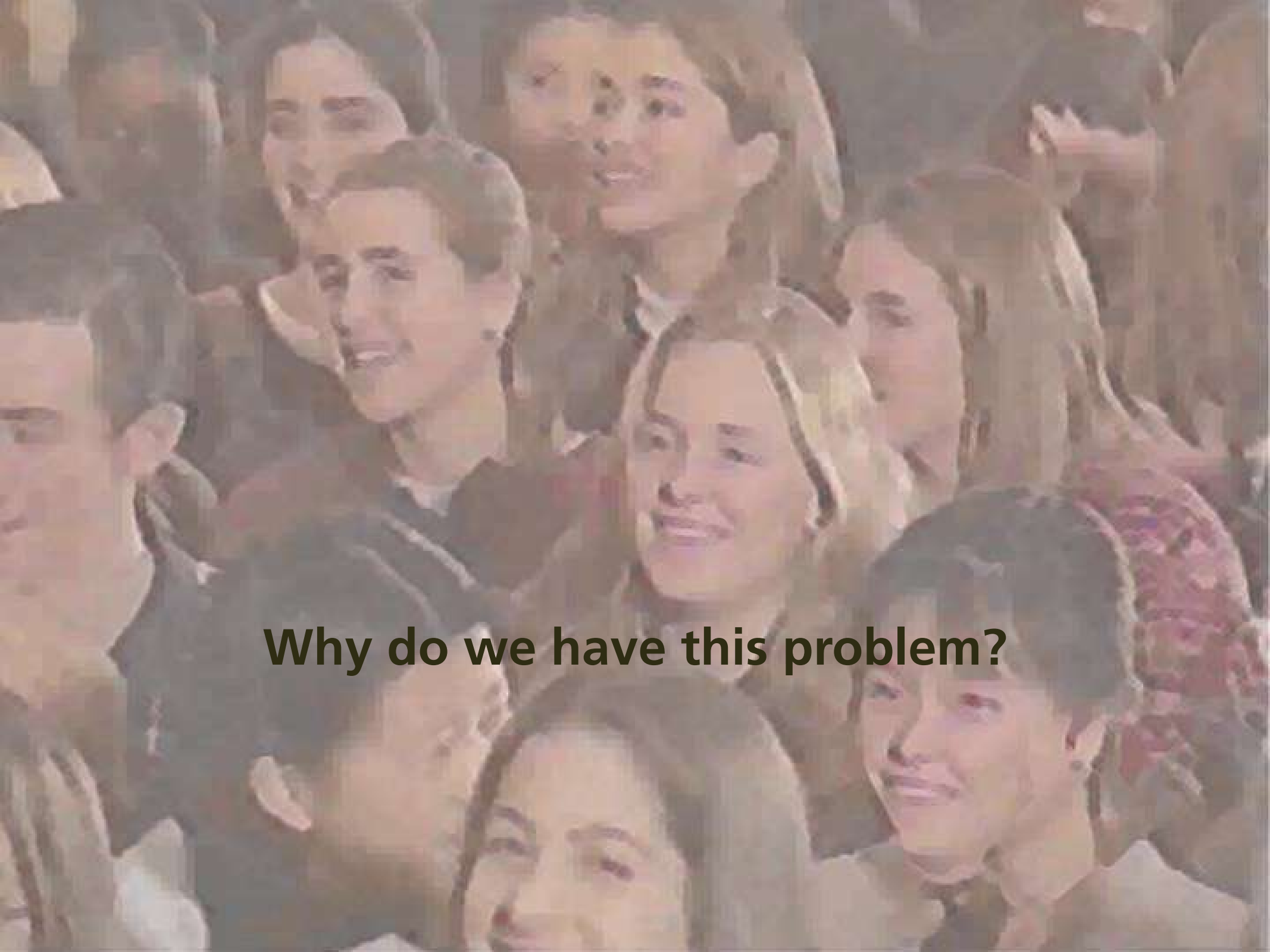
"I took four years of science
and four years of math...

A waste of my time,
a waste of the teacher's time,
and a waste of space...

You know, I took *physics*.

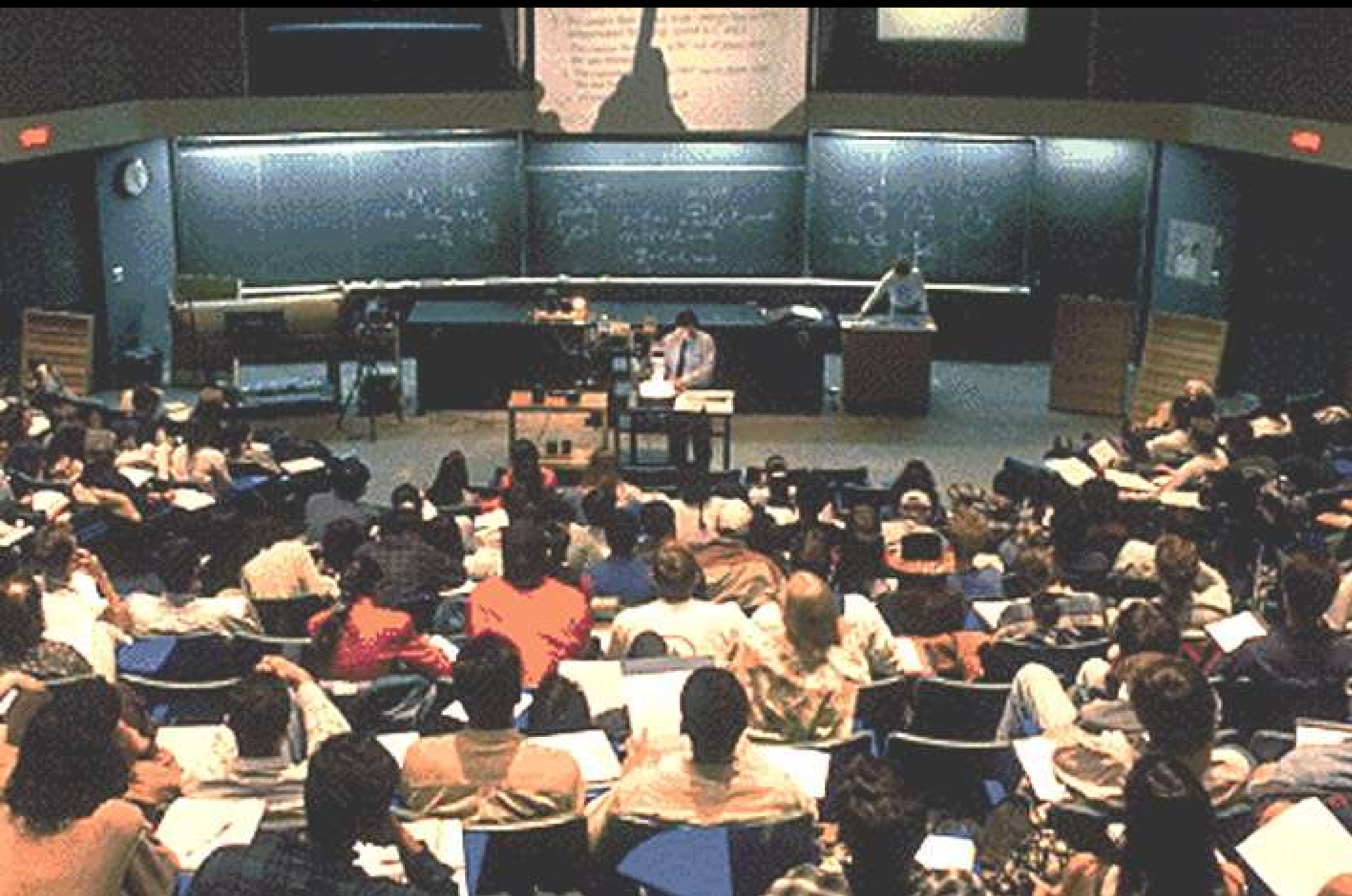
For *what?*"





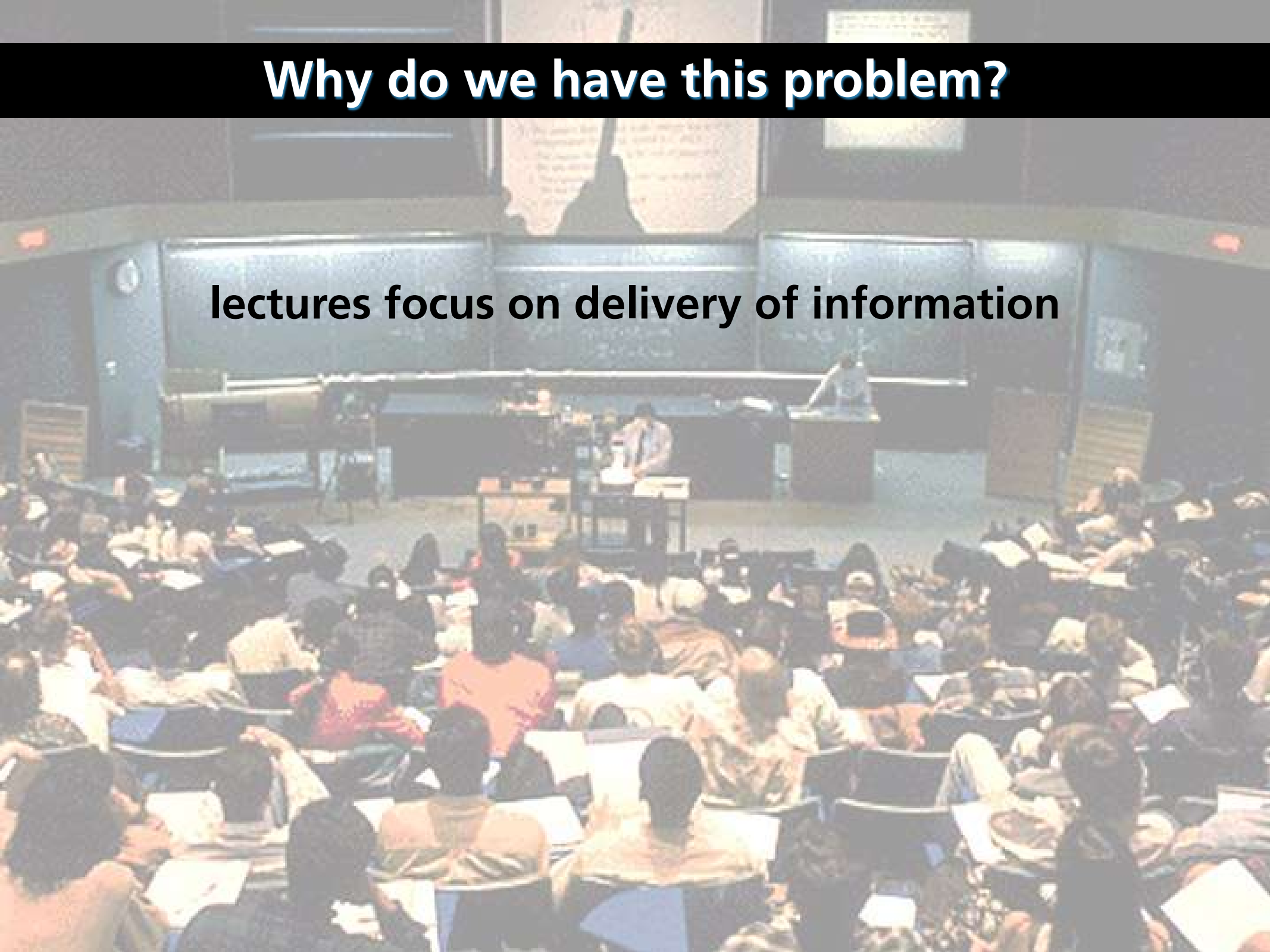
Why do we have this problem?

Why do we have this problem?



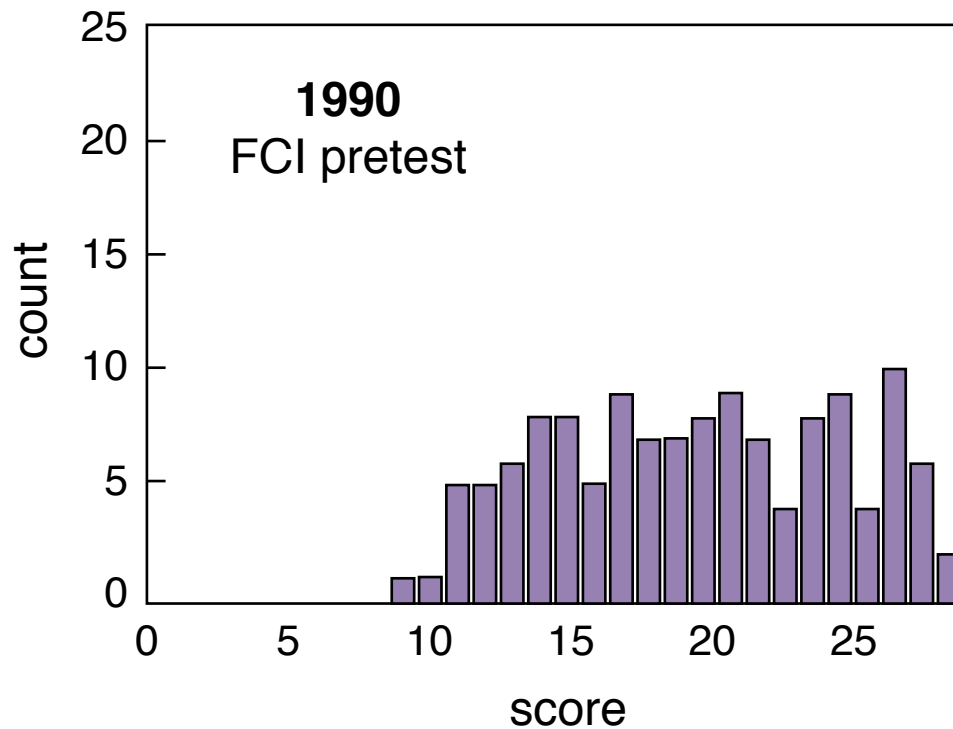
Why do we have this problem?

lectures focus on delivery of information



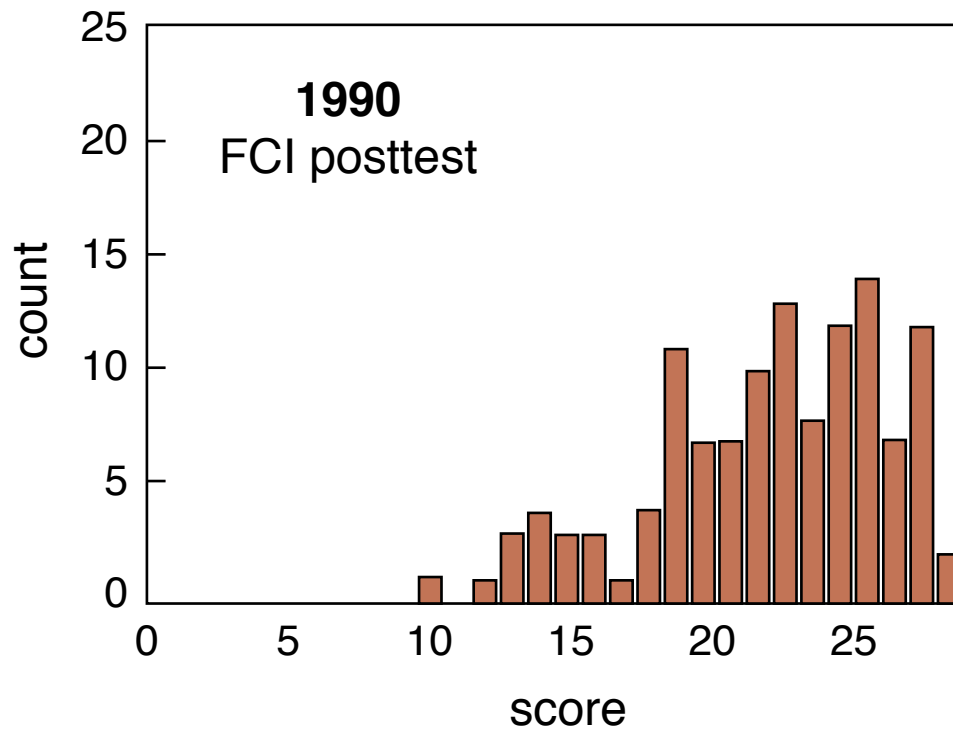
Why do we have this problem?

education is not just information transfer



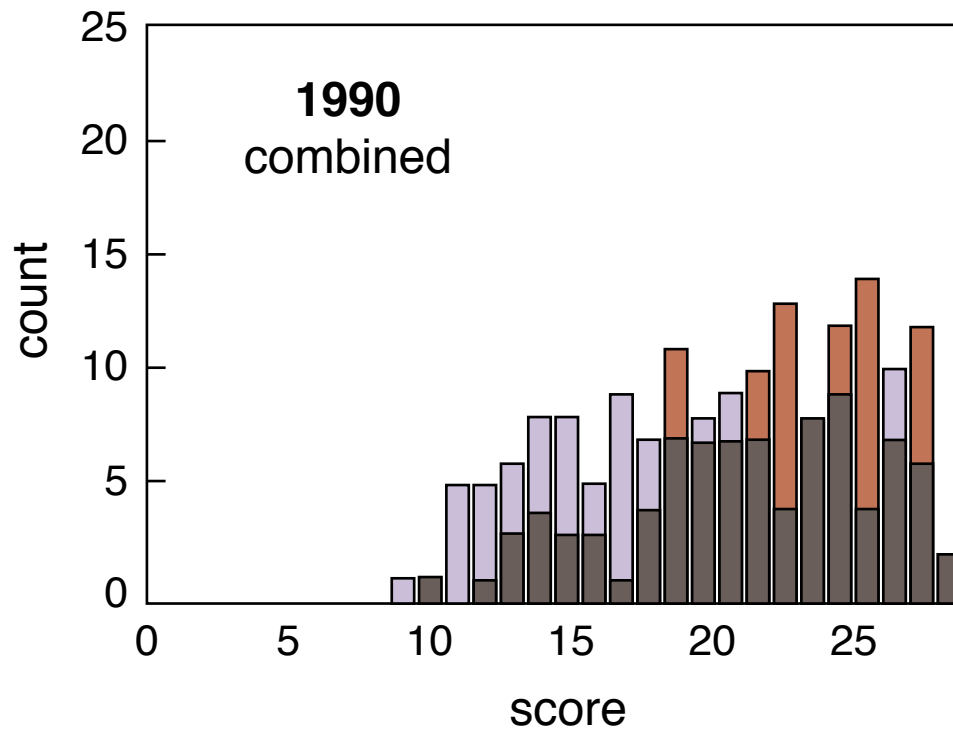
Why do we have this problem?

education is not just information transfer

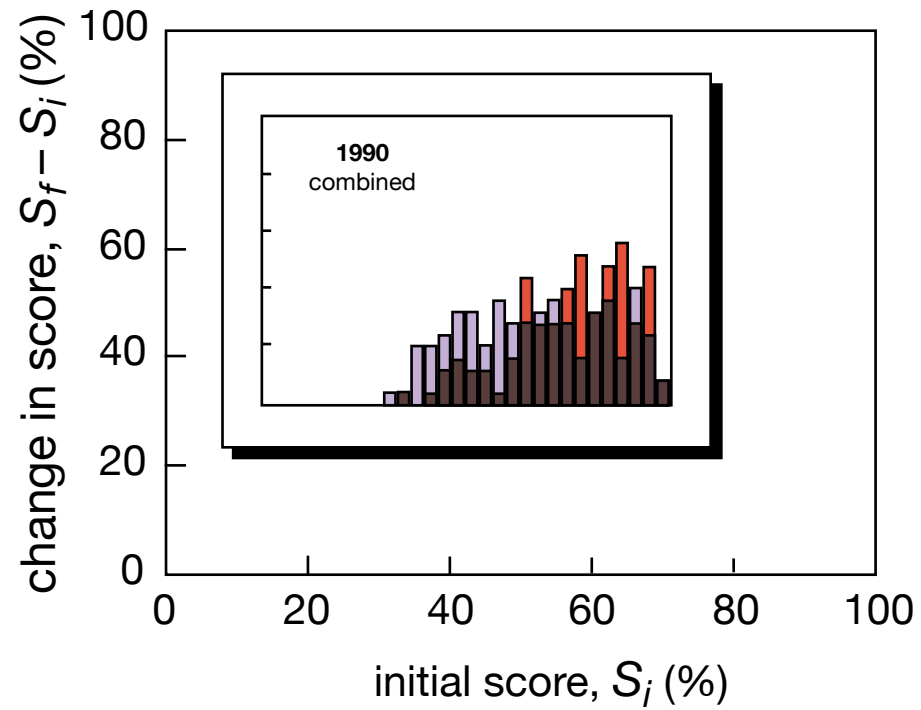


Why do we have this problem?

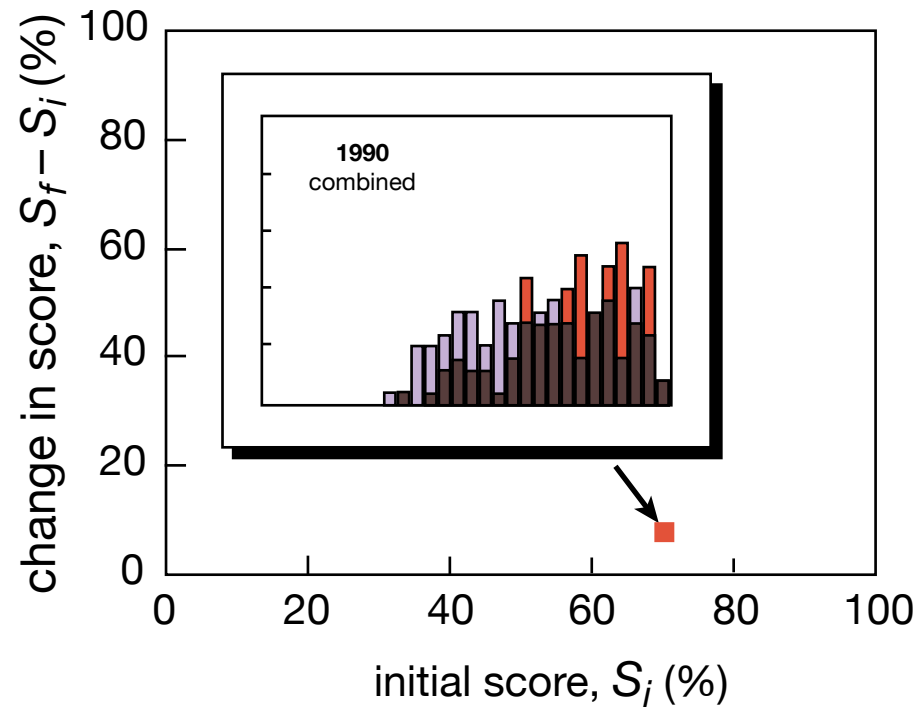
education is not just information transfer



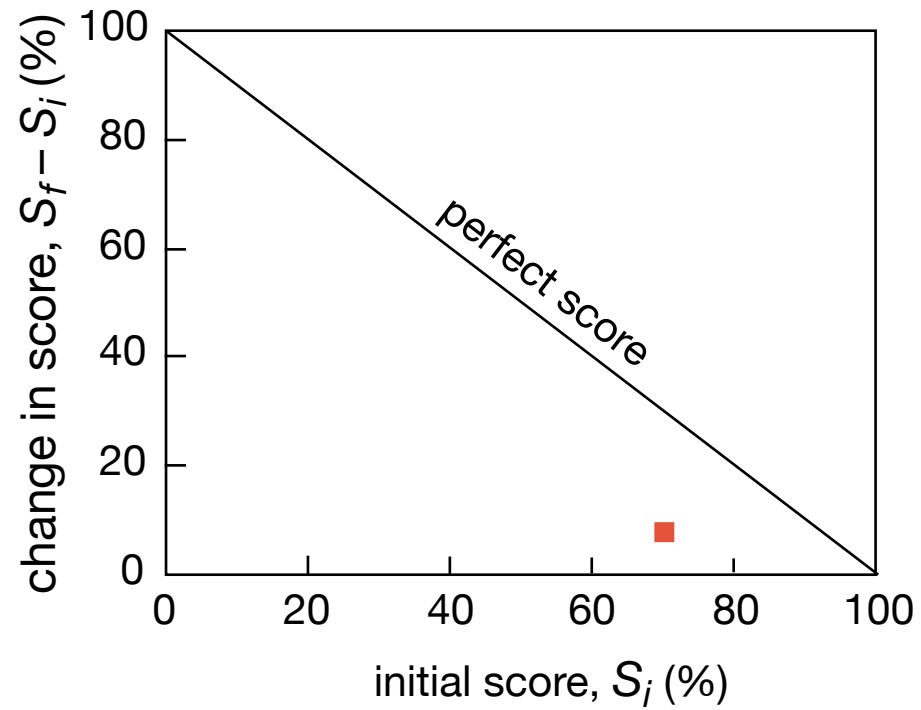
Why do we have this problem?



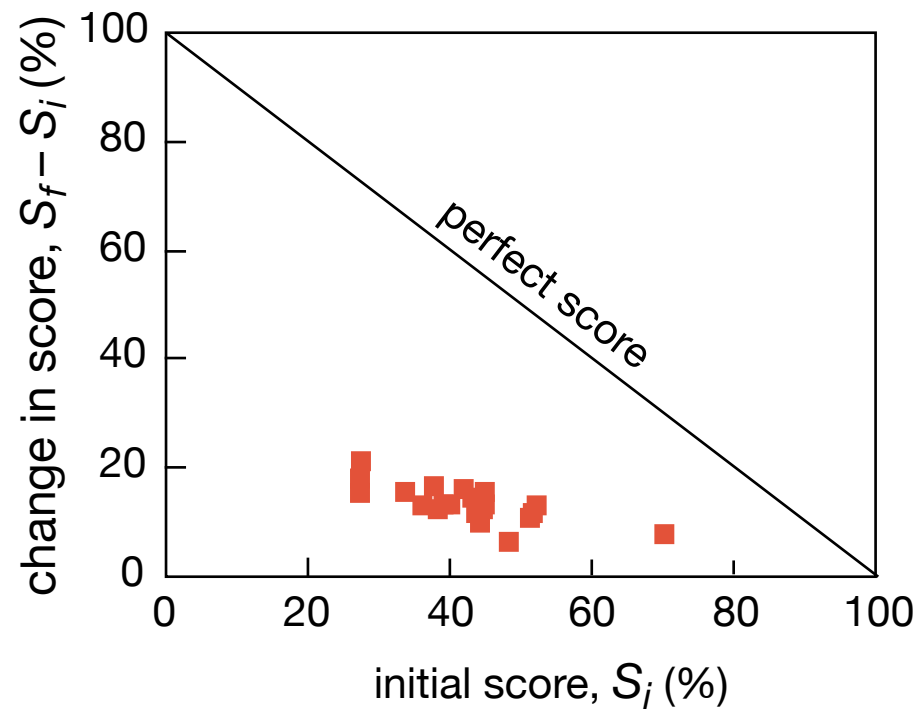
Why do we have this problem?



Why do we have this problem?

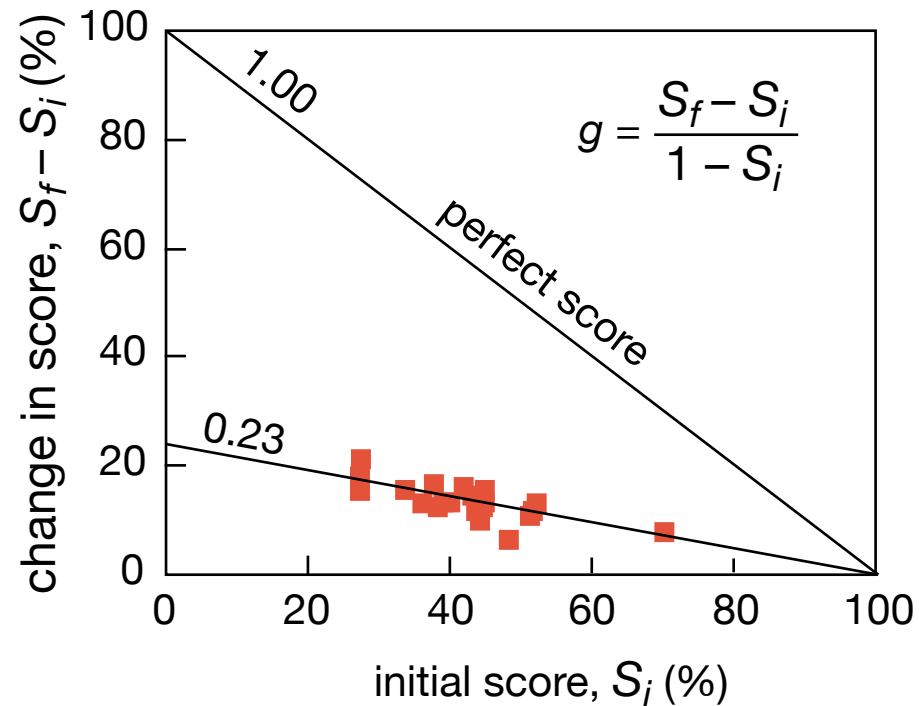


Why do we have this problem?



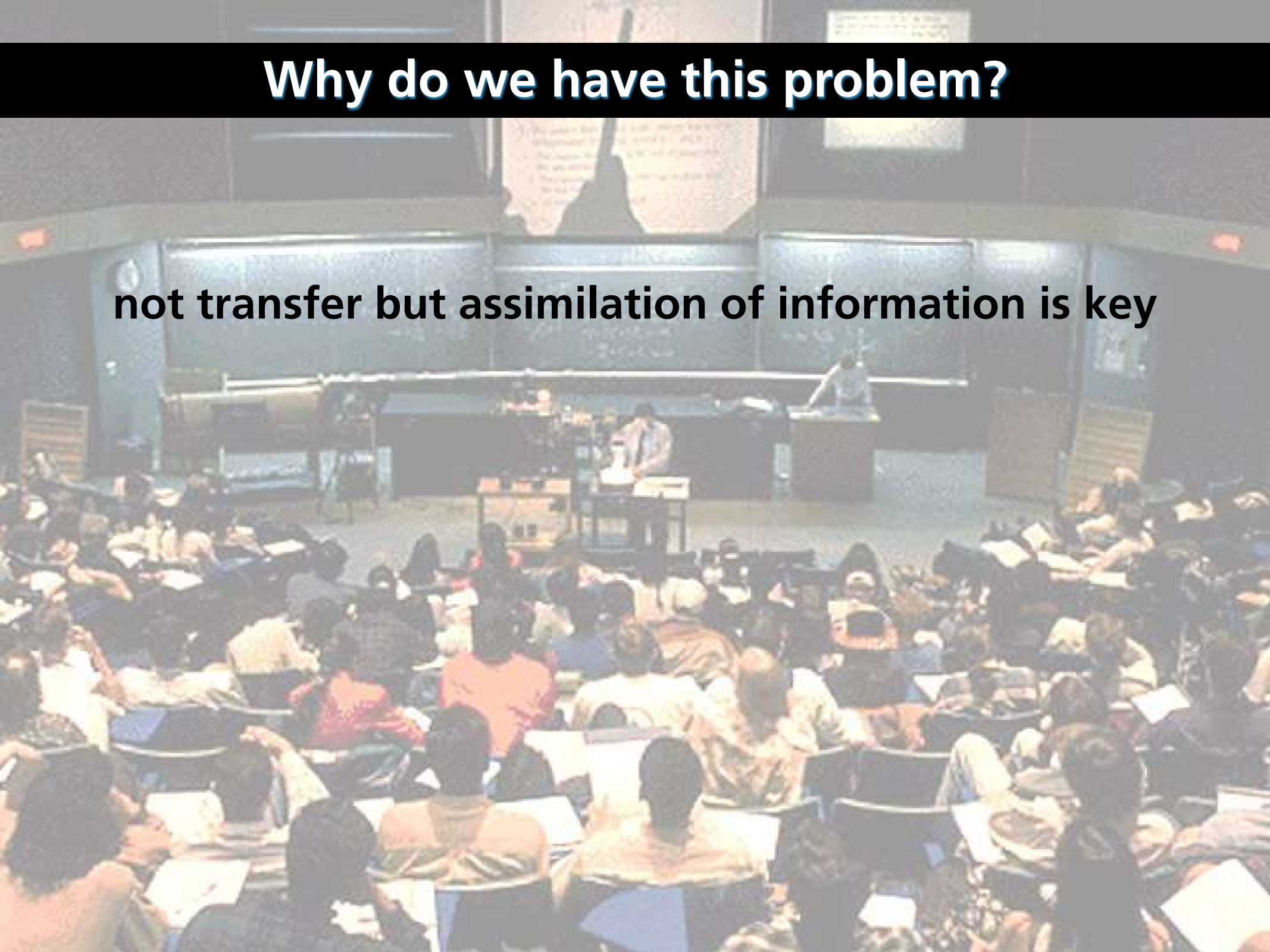
Why do we have this problem?

only one quarter of maximum gain realized



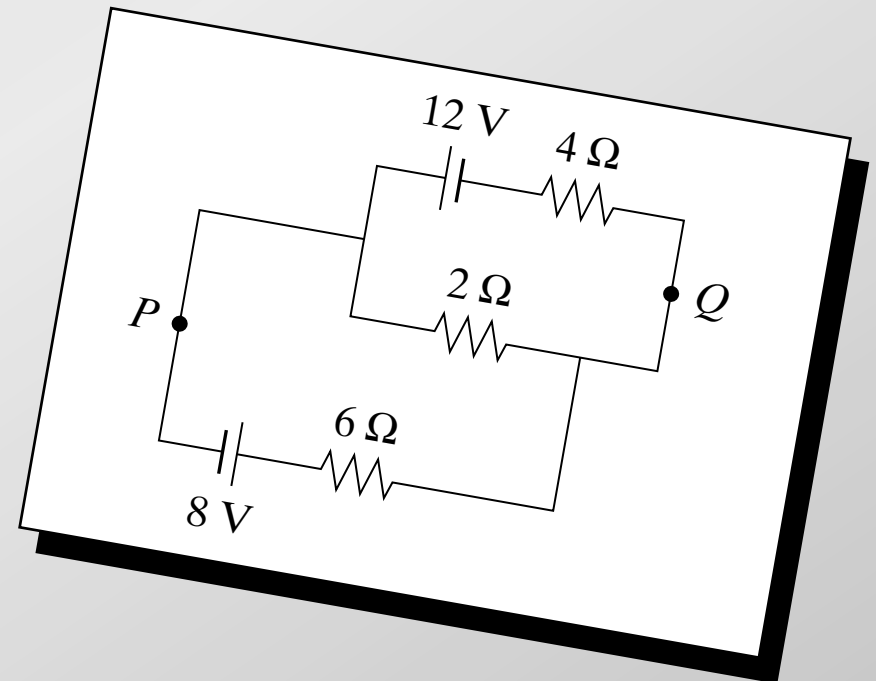
Why do we have this problem?

not transfer but assimilation of information is key



Why do we have this problem?

conventional problems reinforce bad study habits



Why do we have this problem?

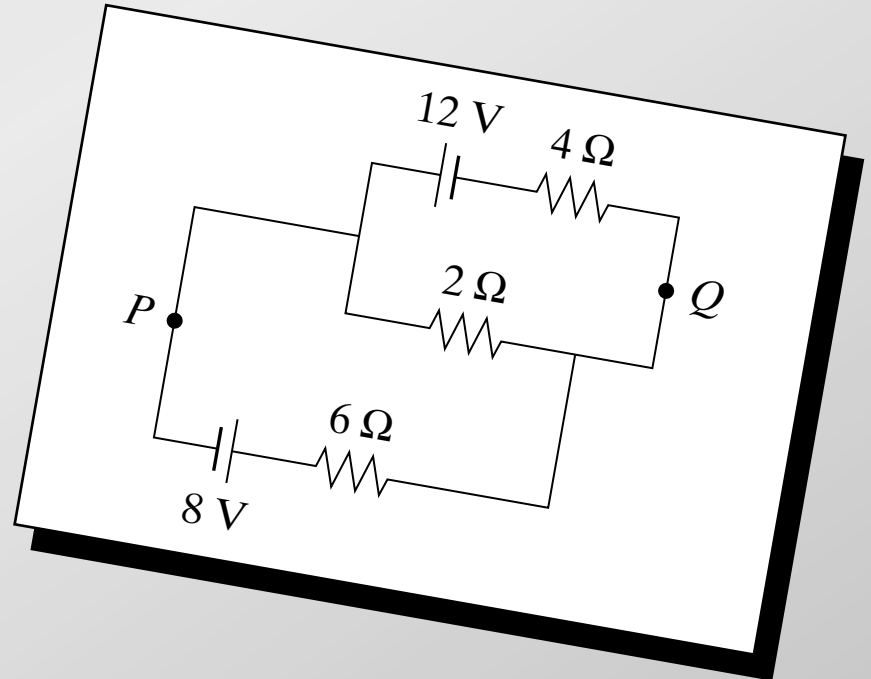
conventional problems reinforce bad study habits

Calculate:

(a) current in $2\text{-}\Omega$ resistor

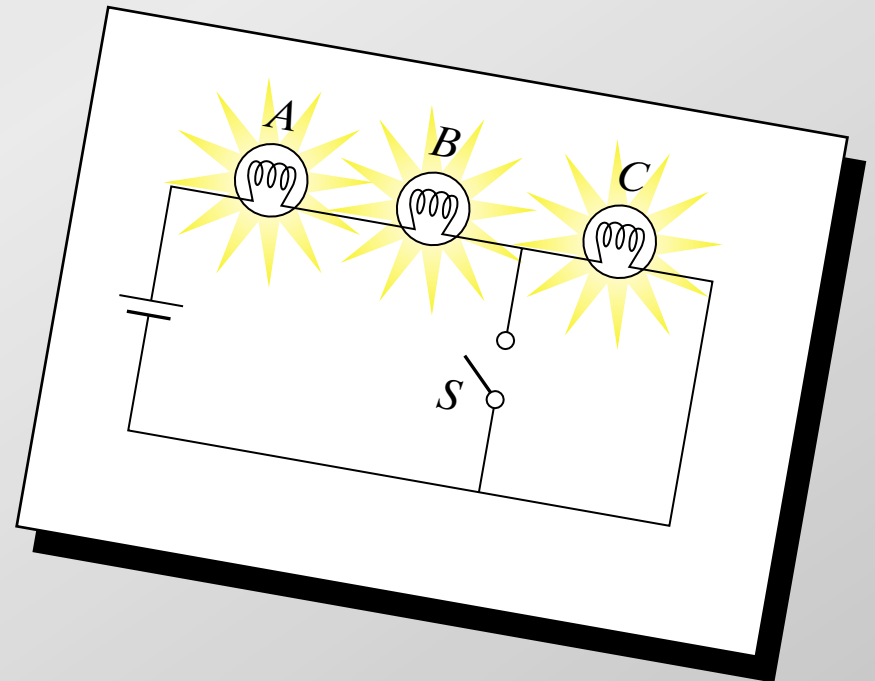
(b) potential difference

between P and Q



Why do we have this problem?

are the basic principles understood?

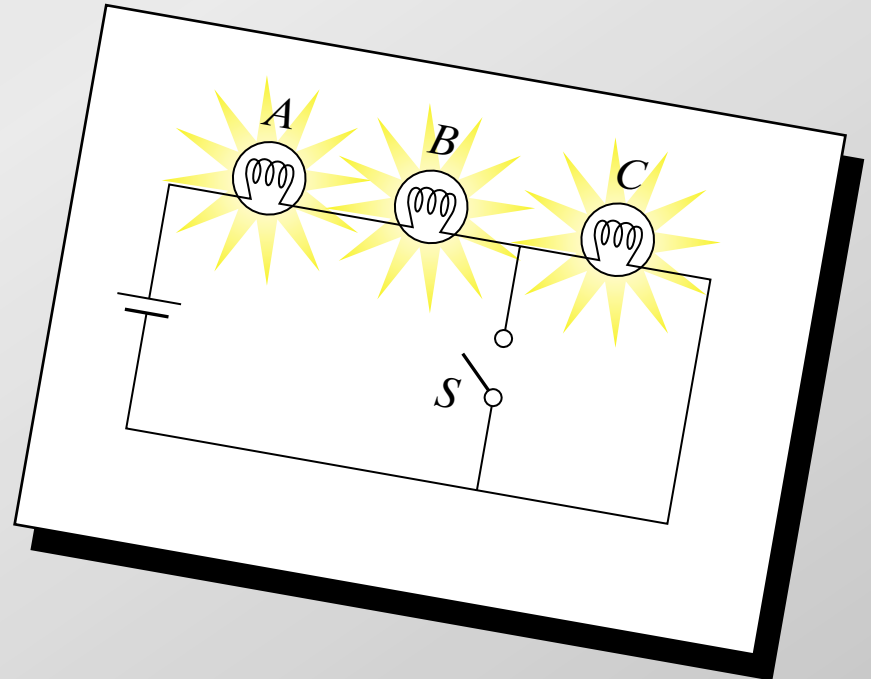


Why do we have this problem?

are the basic principles understood?

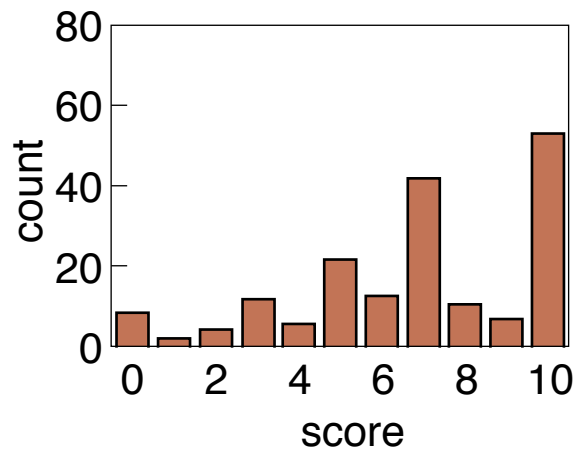
When S is closed, what happens to:

- (a) intensities of A and B ?
- (b) intensity of C ?
- (c) current through battery?
- (d) potential difference across
 A , B , and C ?
- (e) the total power dissipated?

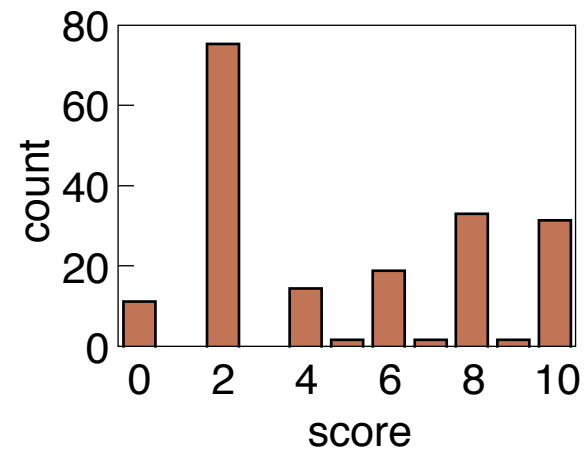


Why do we have this problem?

conventional

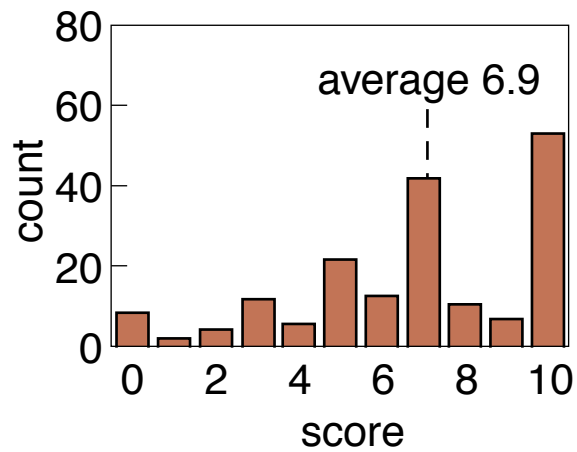


conceptual

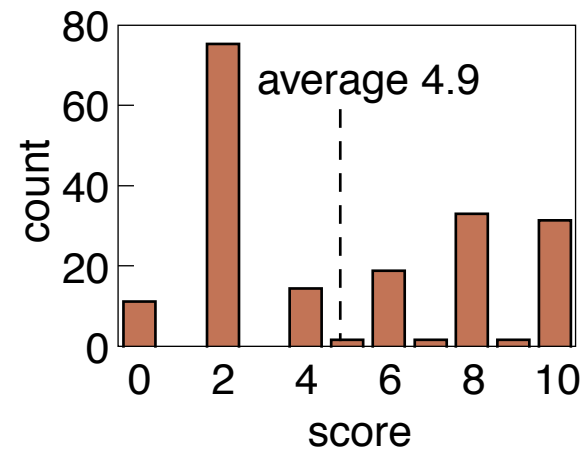


Why do we have this problem?

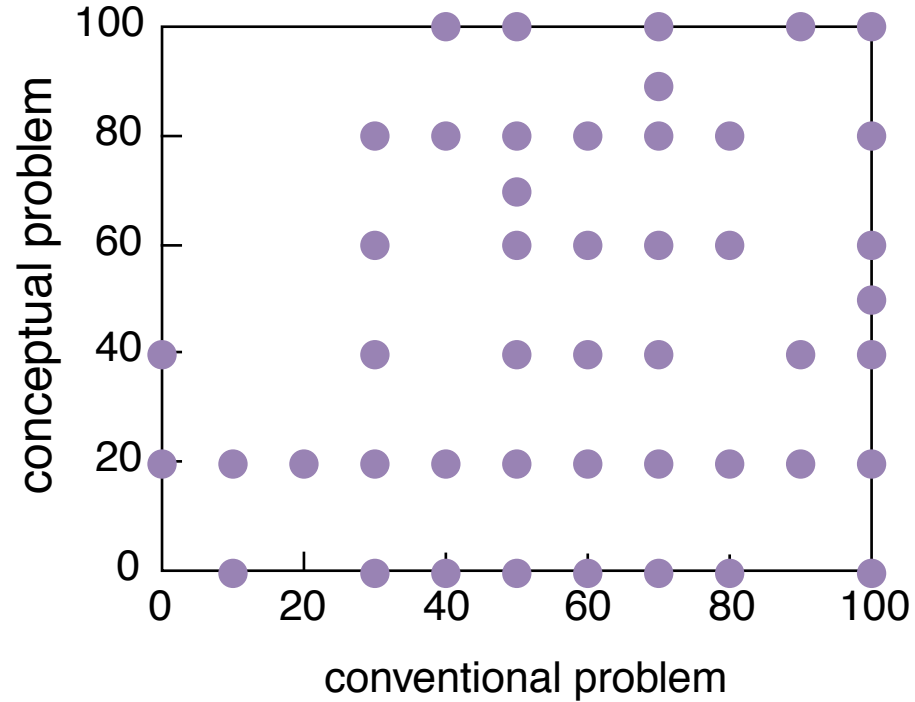
conventional



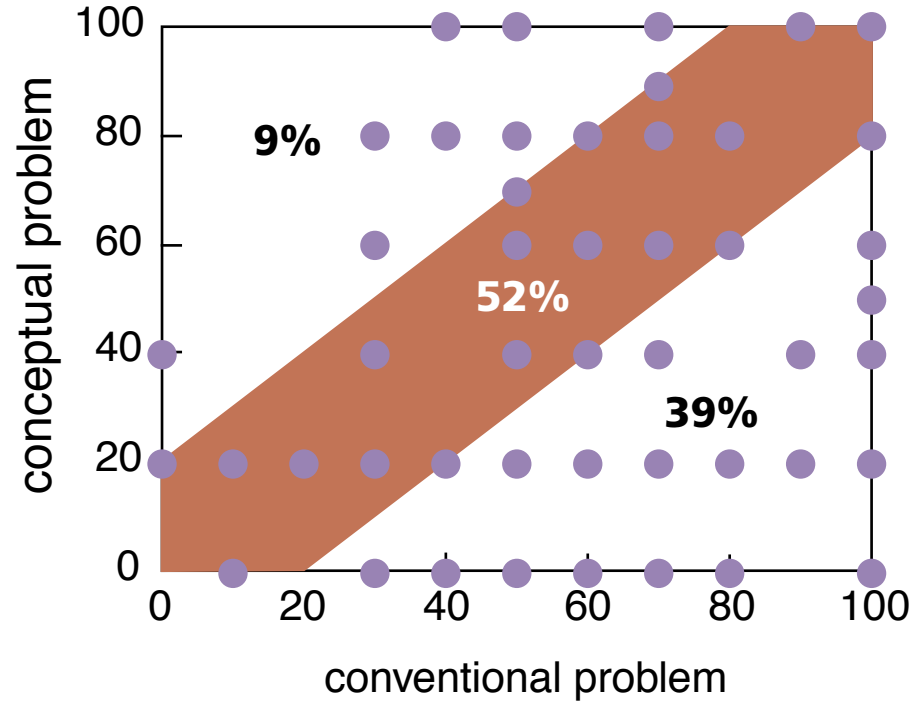
conceptual



Why do we have this problem?



Why do we have this problem?



A large lecture hall with a professor at a podium and students seated at desks. A large screen at the front displays a document with a pen nib. The text "So what should we do?" is overlaid in the center.

So what should we do?

Peer Instruction

Give students more responsibility for gathering information...

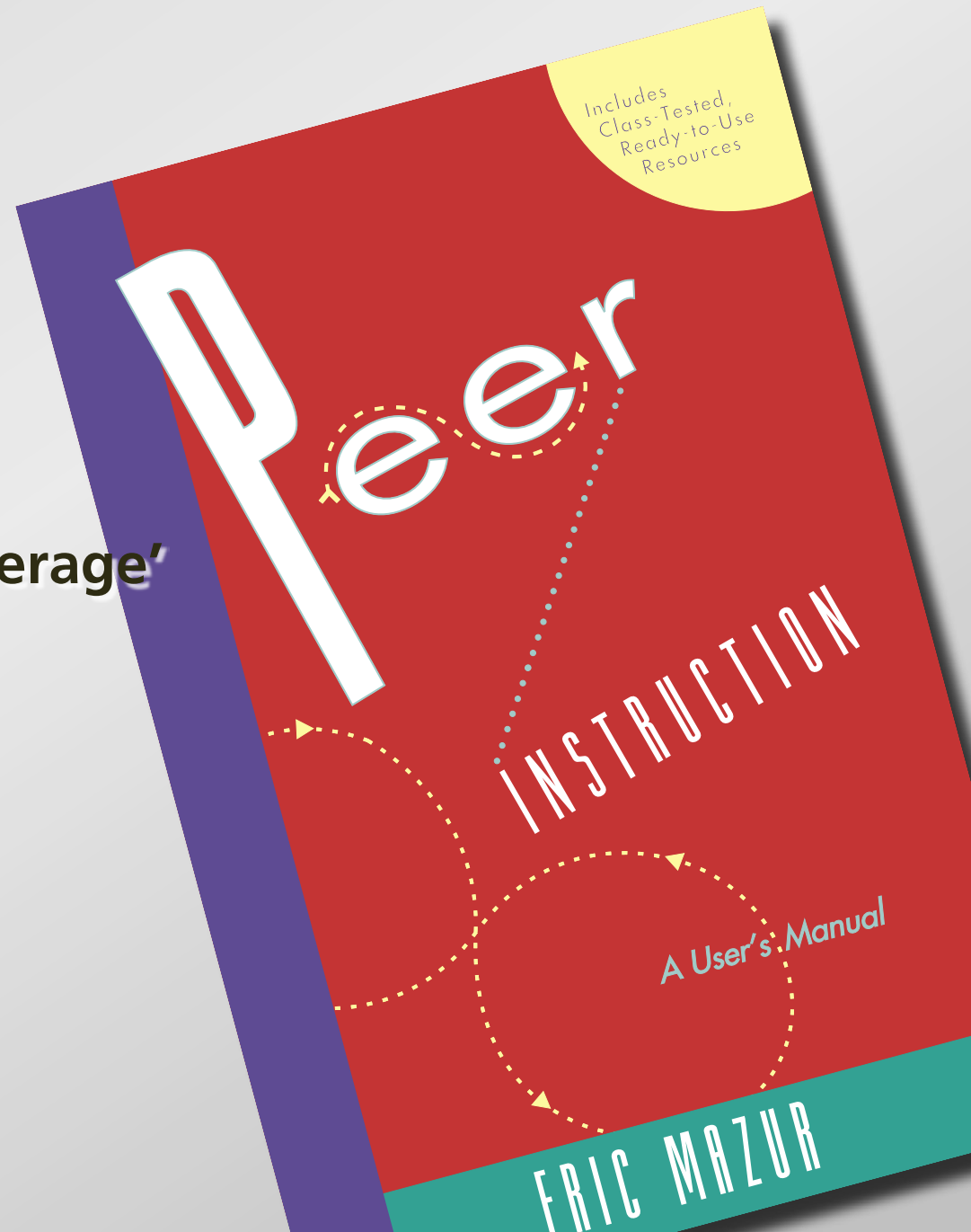
Peer Instruction

**Give students more responsibility for gathering information...
so we can better help them assimilate it.**

Peer Instruction

Main features:

- pre-class reading
- in-class: depth, not 'coverage'
- ConcepTests



Peer Instruction

ConcepTest:

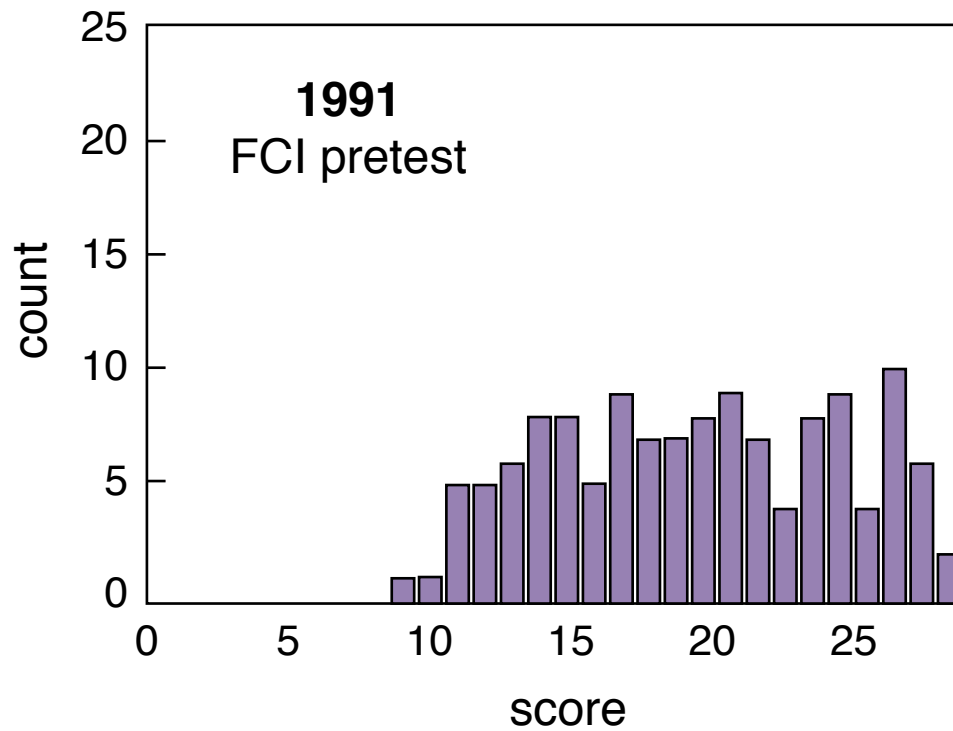
- 1. Question**
- 2. Thinking**
- 3. Individual answer**
- 4. Peer discussion**
- 5. Revised/Group answer**
- 6. Explanation**

Peer Instruction

is it any good?

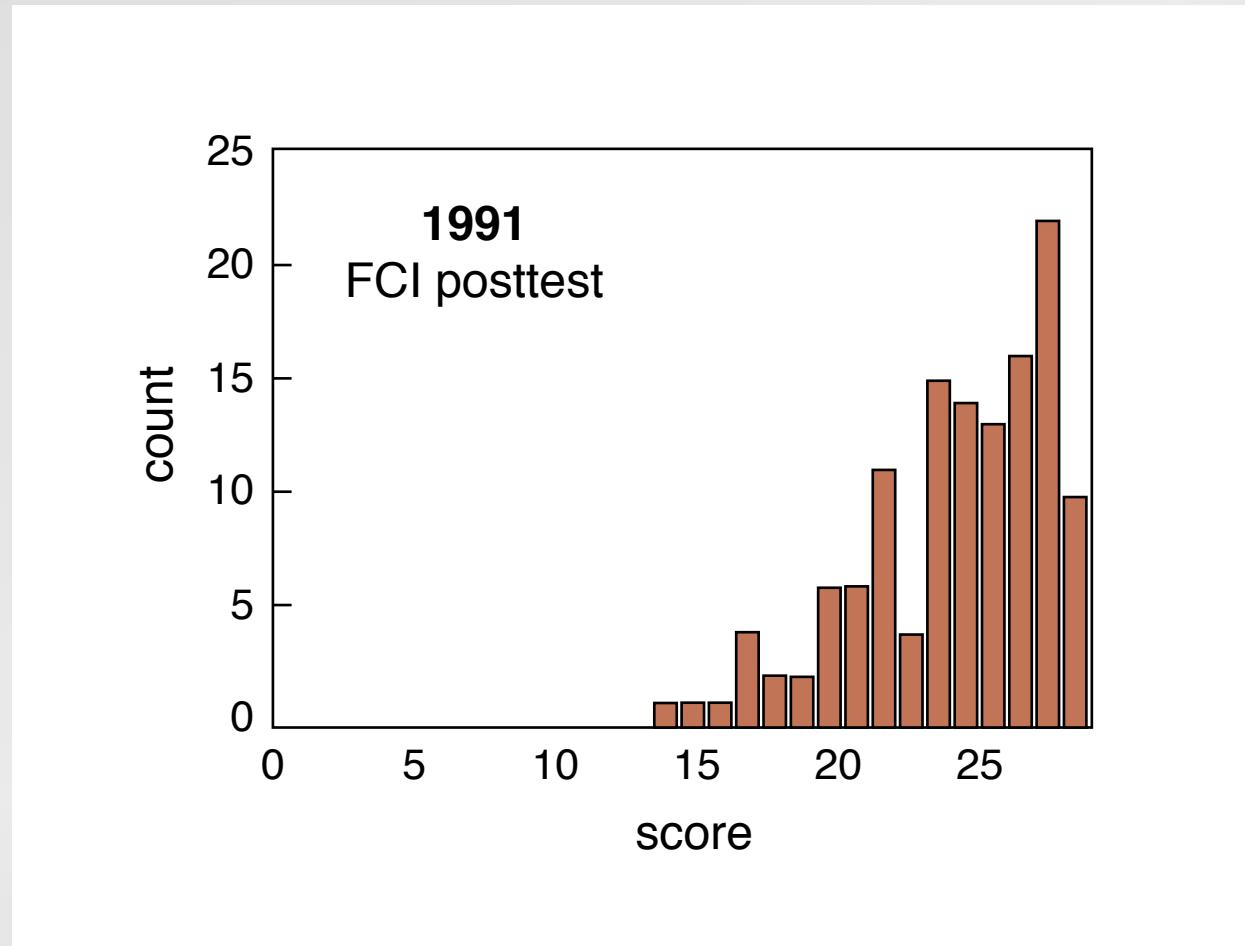
Peer Instruction

first year of implementing PI



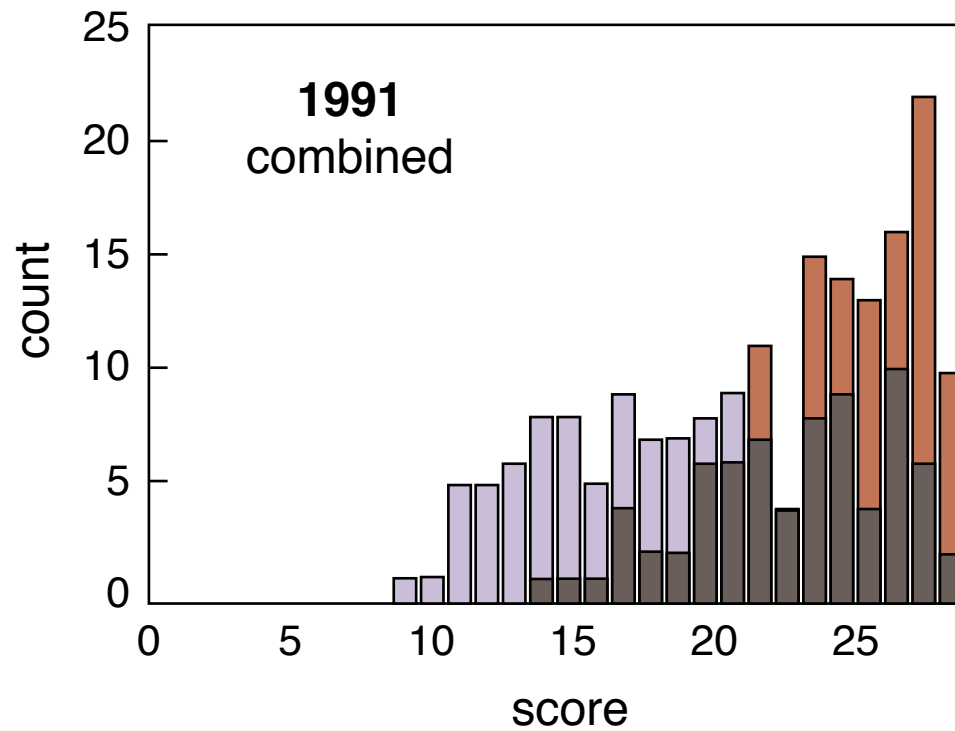
Peer Instruction

first year of implementing PI

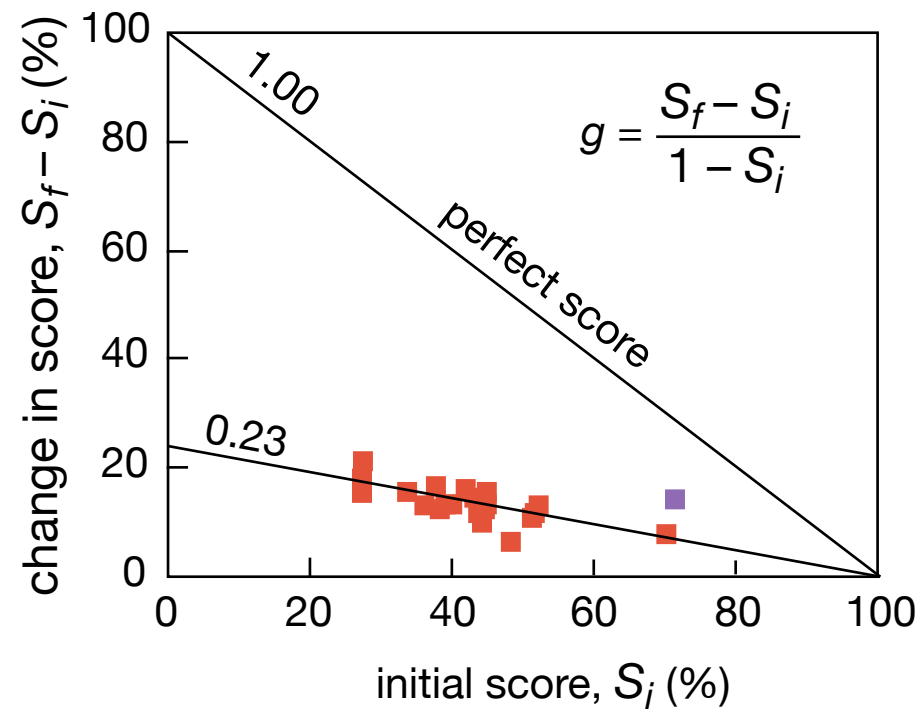


Peer Instruction

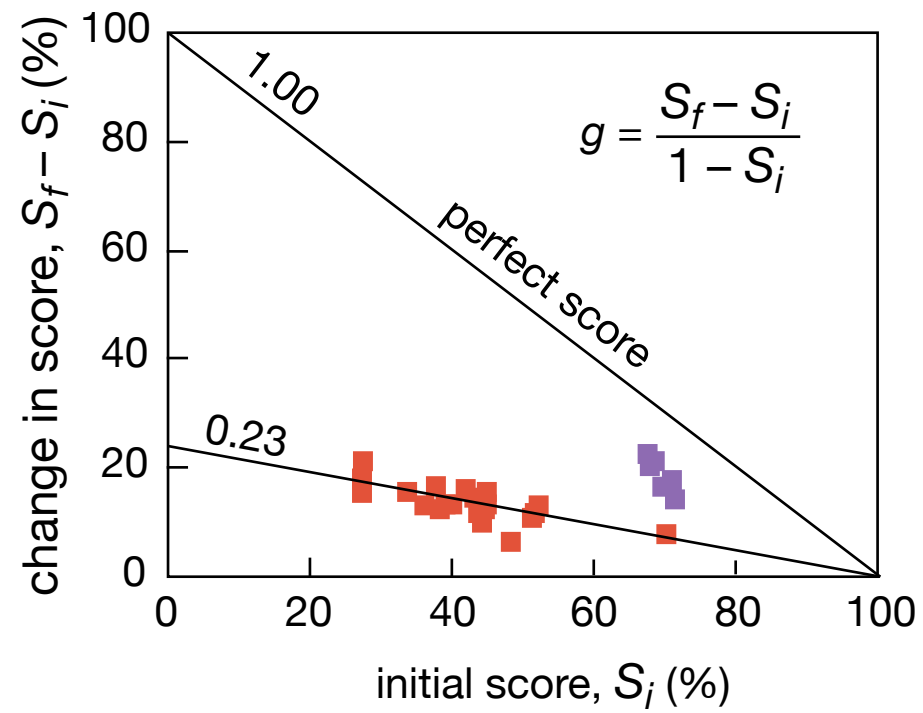
first year of implementing PI



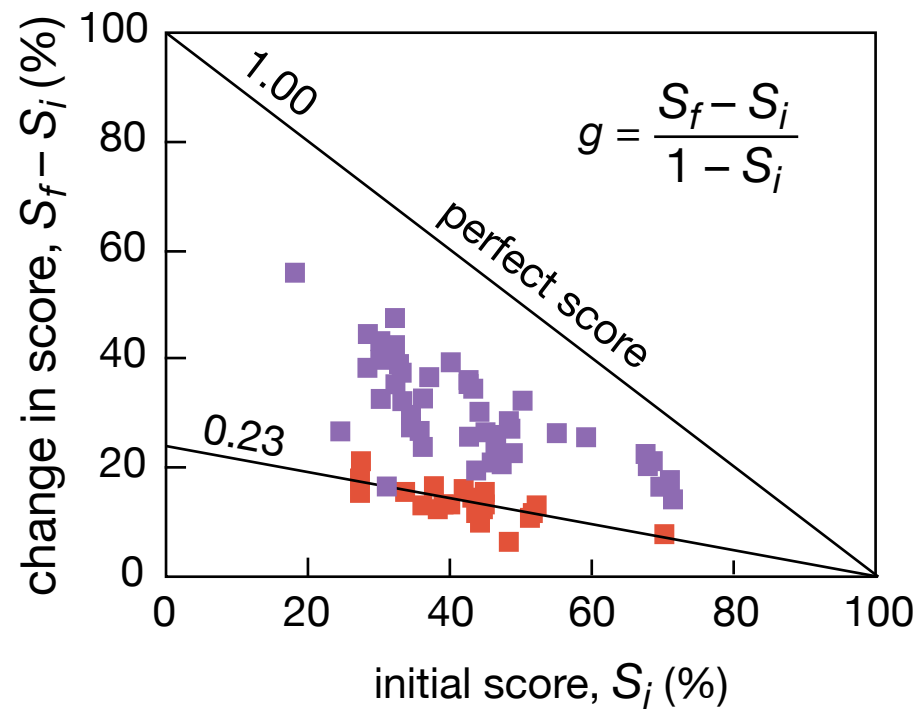
Peer Instruction



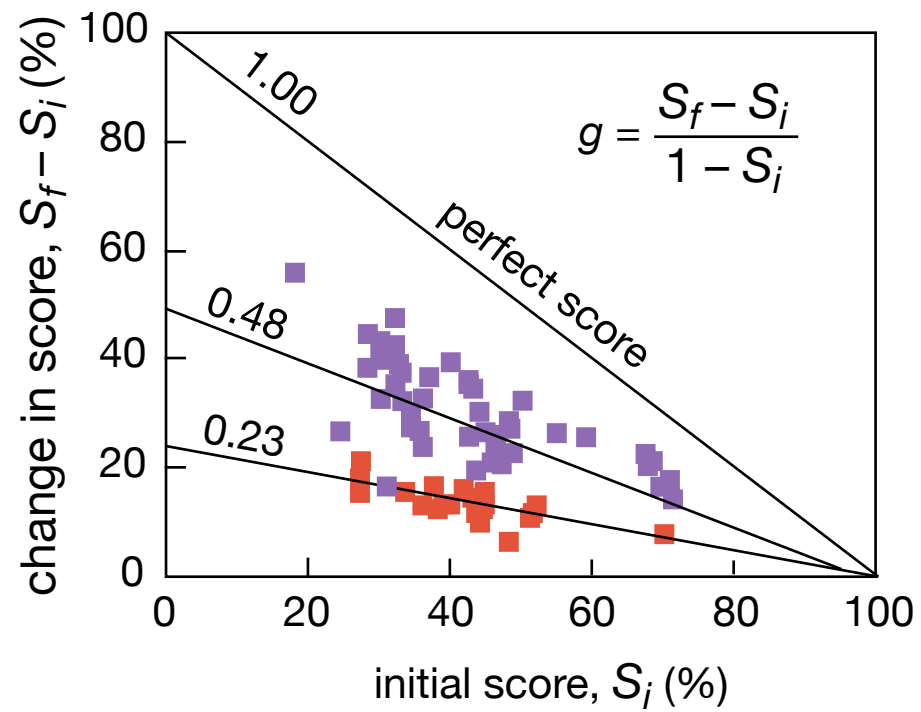
Peer Instruction



Peer Instruction



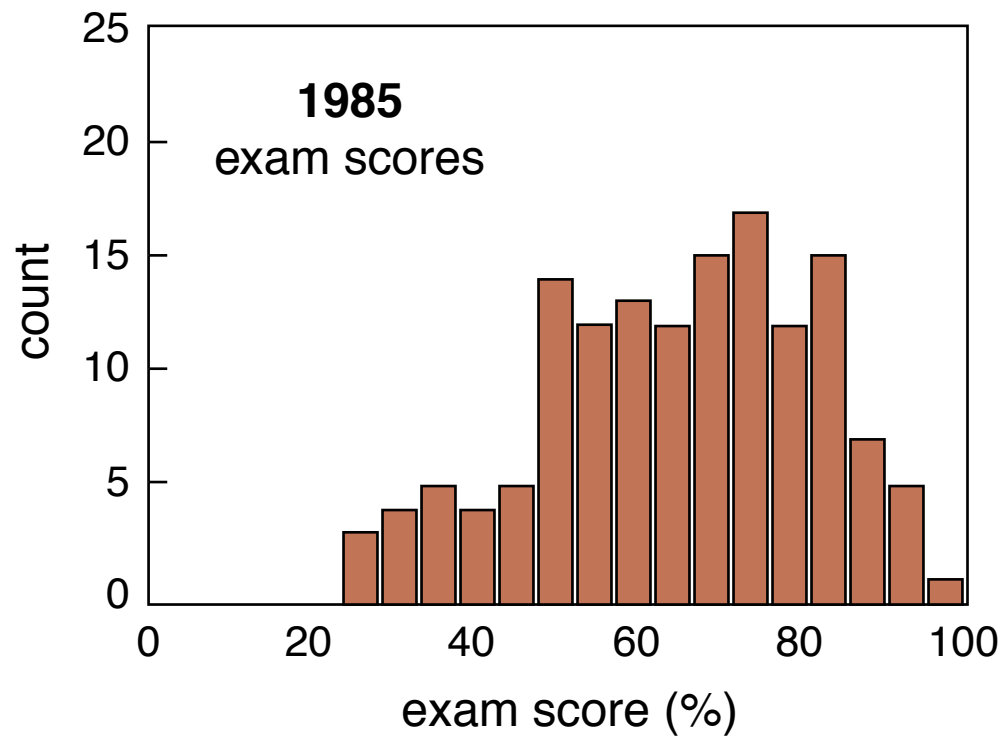
Peer Instruction



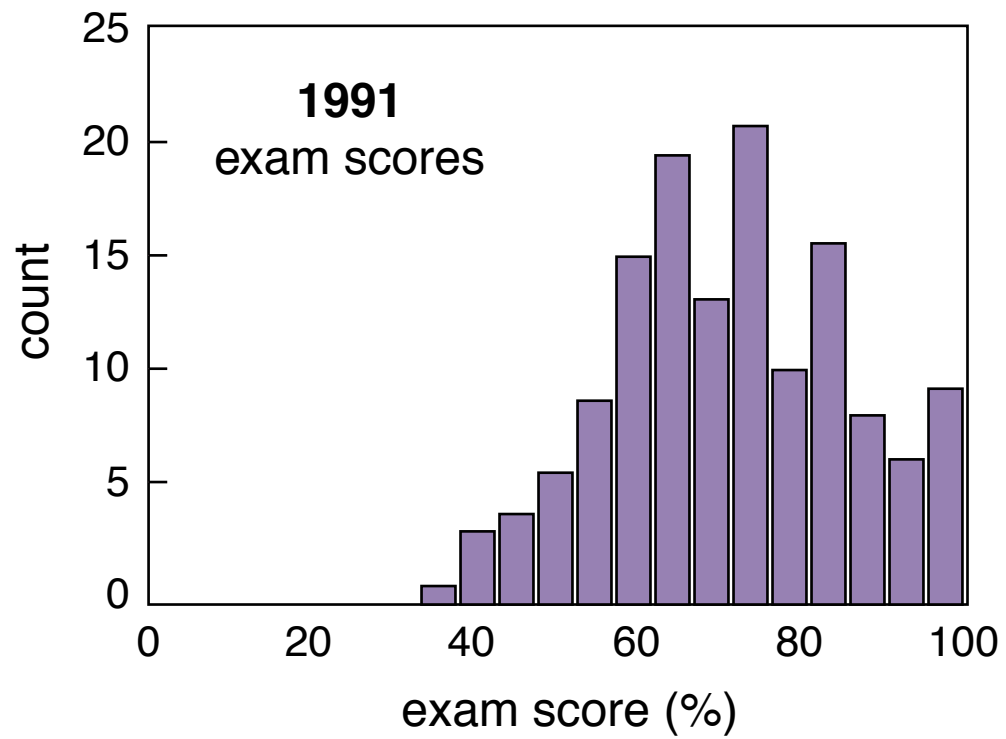
Peer Instruction

what about problem solving?

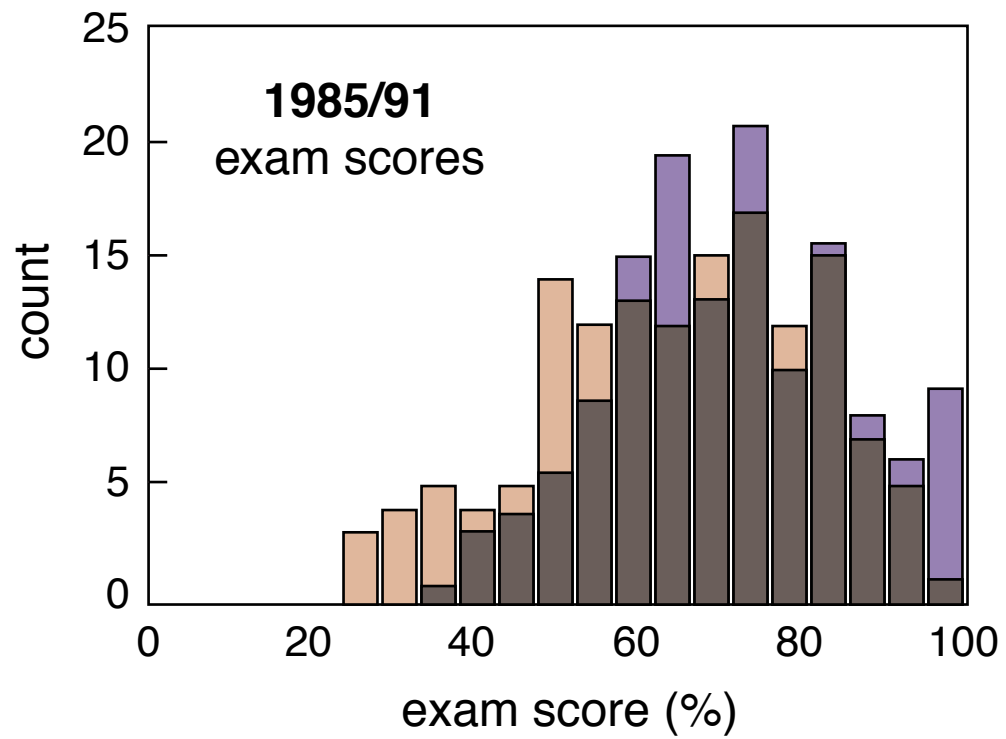
Peer Instruction



Peer Instruction



Peer Instruction



Peer Instruction

**So better understanding leads to better
problem solving!**

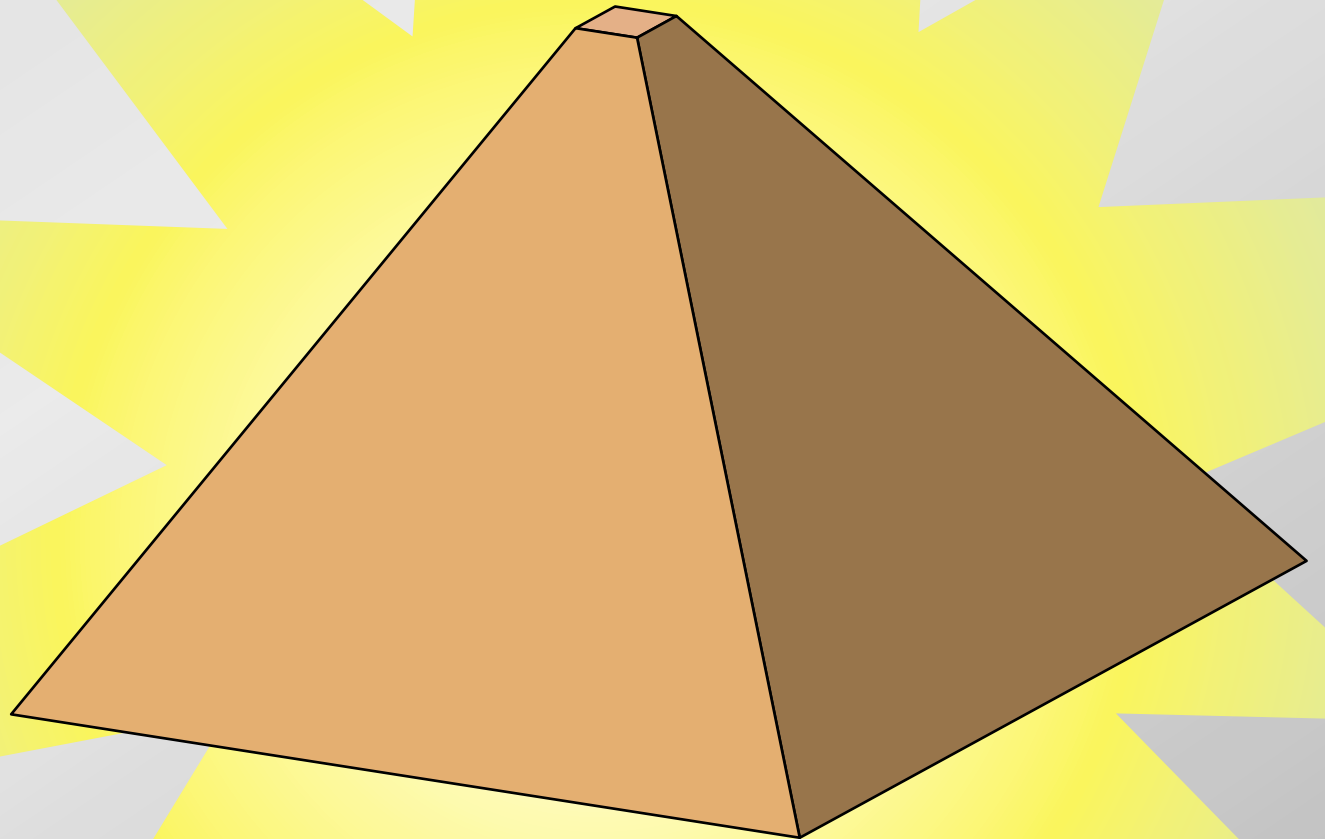
Peer Instruction

So better understanding leads to better problem solving!

(but “good” problem solving doesn’t always indicate understanding!)

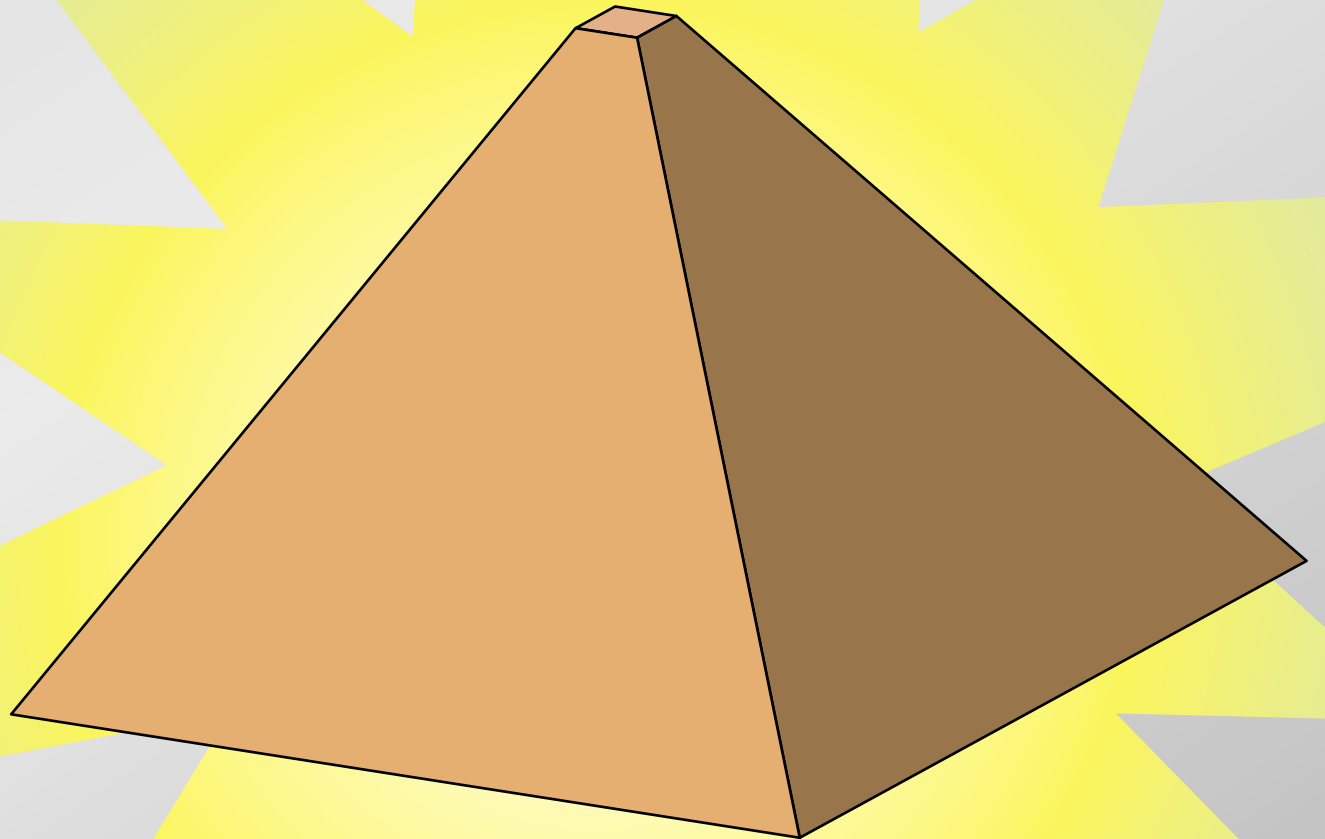
Conclusion

Let's not forget the base
of the pyramid



Conclusion

Let's give them something
of value!



Funding:

National Science Foundation

for a copy of this presentation:

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

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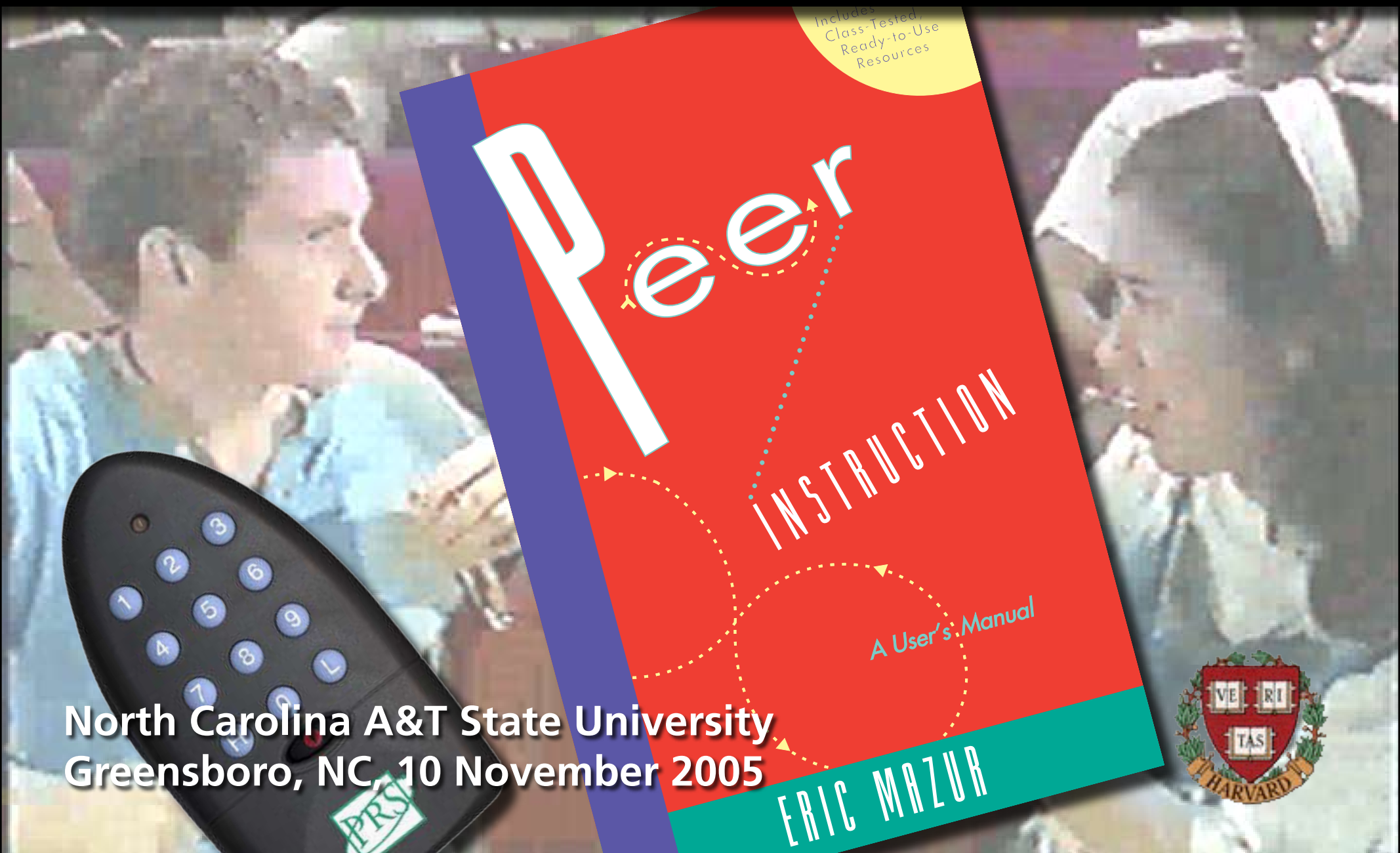
Funding:

National Science Foundation

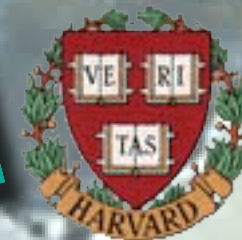
for a copy of this presentation:

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Peer Instruction: Discussion and 'brains-on' demo



North Carolina A&T State University
Greensboro, NC, 10 November 2005



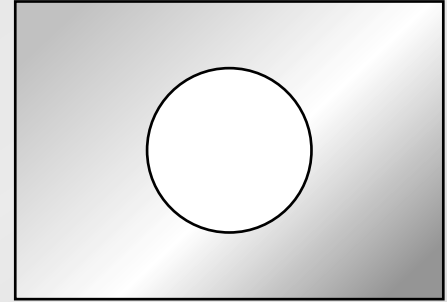
Outline

Some options:

- **Let's try it!**
- **Feedback methods**
- **Research: providing the basis for change**
- **Problems with problems**
- **Resources**
- **Barriers to reform**

Let's try it!

Consider a rectangular metal plate with a circular hole in it.

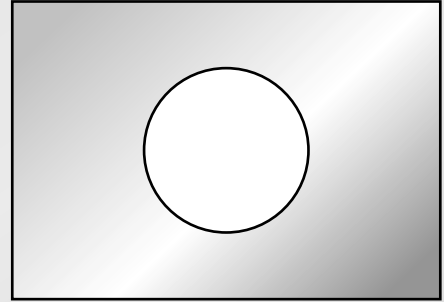


Let's try it!

Consider a rectangular metal plate with a circular hole in it.

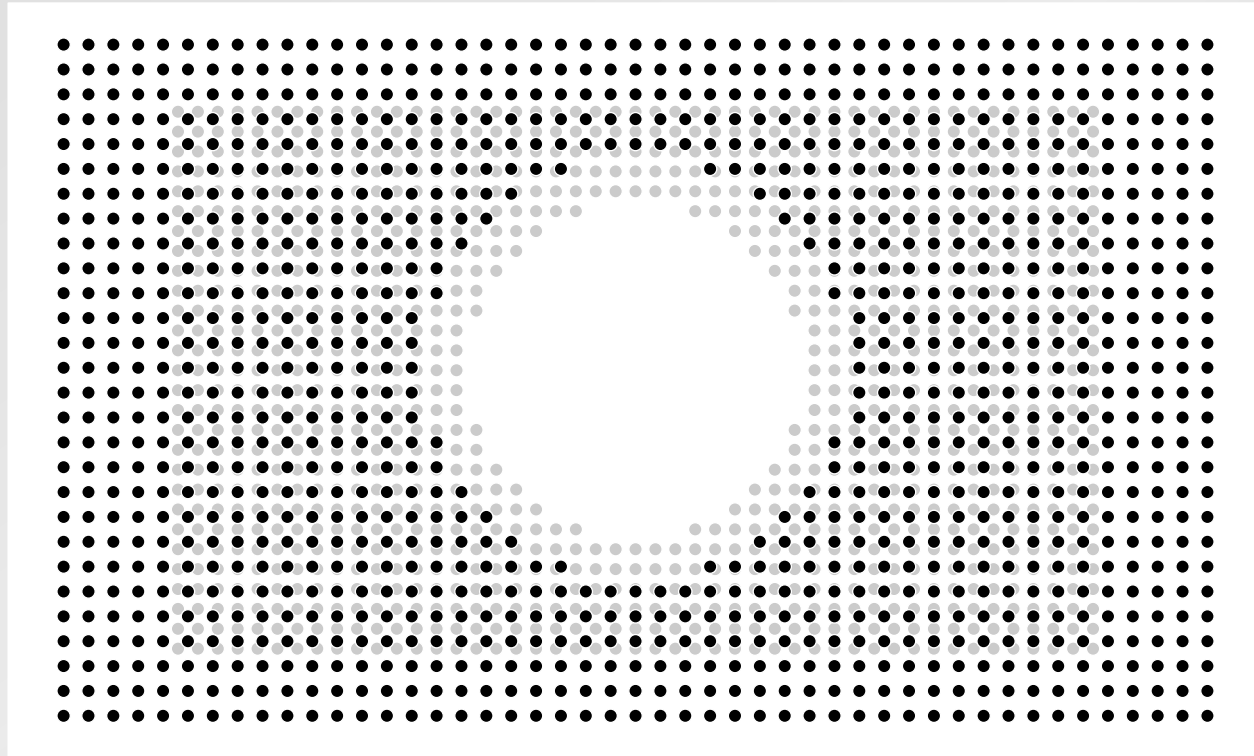
When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.



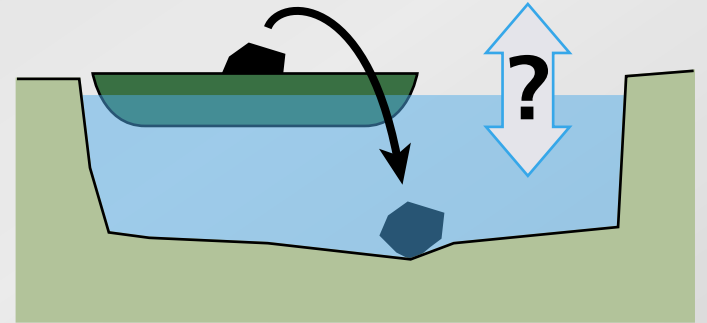
Let's try it!

The distance between the atoms increases uniformly



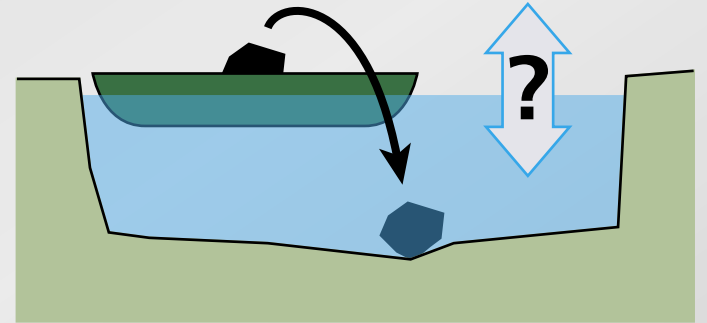
Let's try it!

A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.



Let's try it!

A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.



After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than
2. the same as
3. lower than

it was when the boulder was in the boat.

Let's try it!

When we hold a page of printed text in front of a mirror, the text on the image in the mirror runs from right to left:

The New York Times

Let's try it!

When we hold a page of printed text in front of a mirror, the text on the image in the mirror runs from right to left:

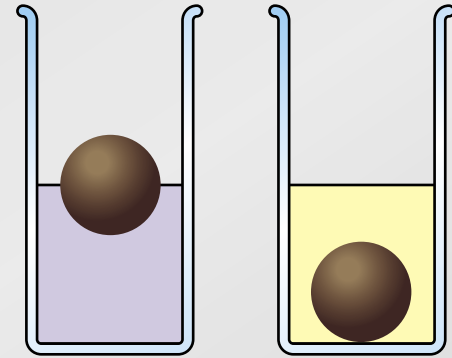
The New York Times

Why is it that right and left are interchanged and not top and bottom? Because:

1. the mirror is oriented vertically.
2. we have two eyes in the horizontal plane.
3. the Earth's gravitation is directed downward.
4. a habit we have when looking at images in a mirror.
5. It only *appears* to run from left to right.

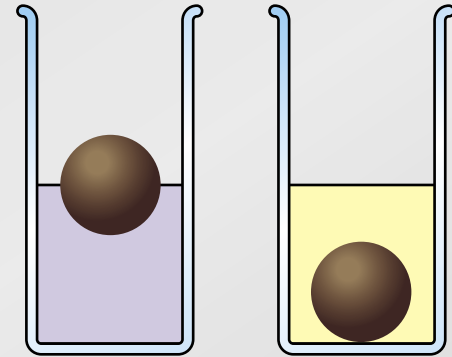
Let's try it!

Consider an object that floats in water, but sinks in oil. When the object floats in water, half of it is submerged.



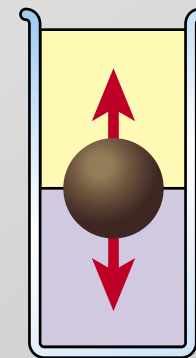
Let's try it!

Consider an object that floats in water, but sinks in oil. When the object floats in water, half of it is submerged.



If we slowly pour the oil on top of the water so it completely covers the object, the object

1. moves up.
2. stays in the same place.
3. moves down.



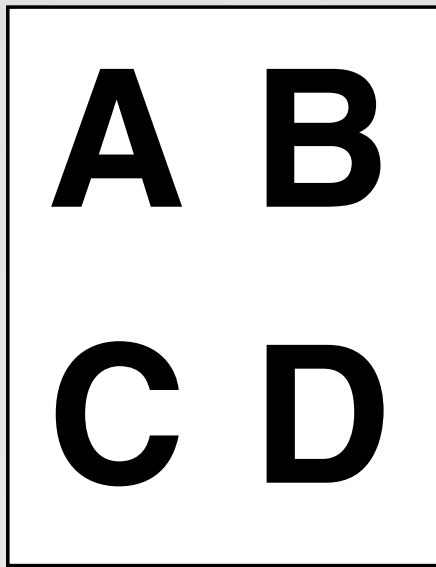
Feedback methods

Show of hands:

easy, but only moderately effective

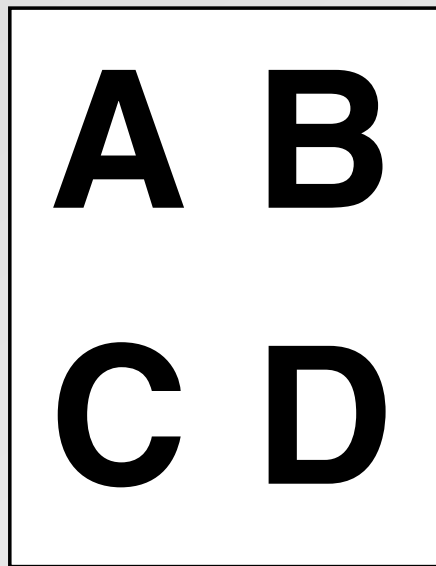
Feedback methods

Flashcards: simple and effective



Feedback methods

Flashcards: simple and effective



Meltzer and Mannivanan, South Eastern Louisiana University

Feedback methods

Infrared transmitters (PRS): easy collection of data



Feedback methods

Infrared transmitters (PRS): easy collection of data



Kristy Beauvais, Concord Carlisle High School

Feedback methods

near future: wireless classroom



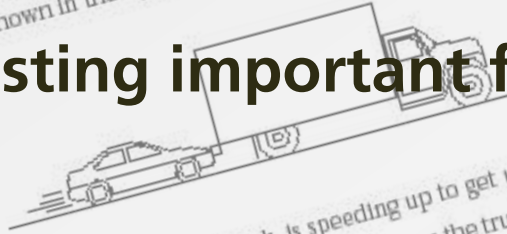
Research: providing the basis for change

Pre/post-testing important for:

- justifying approach
- improving implementation

Use the statement and figure below to answer the next two questions (15 and 16).

A large truck breaks down on the road and receives a push back into town by a compact car as shown in the figure below.



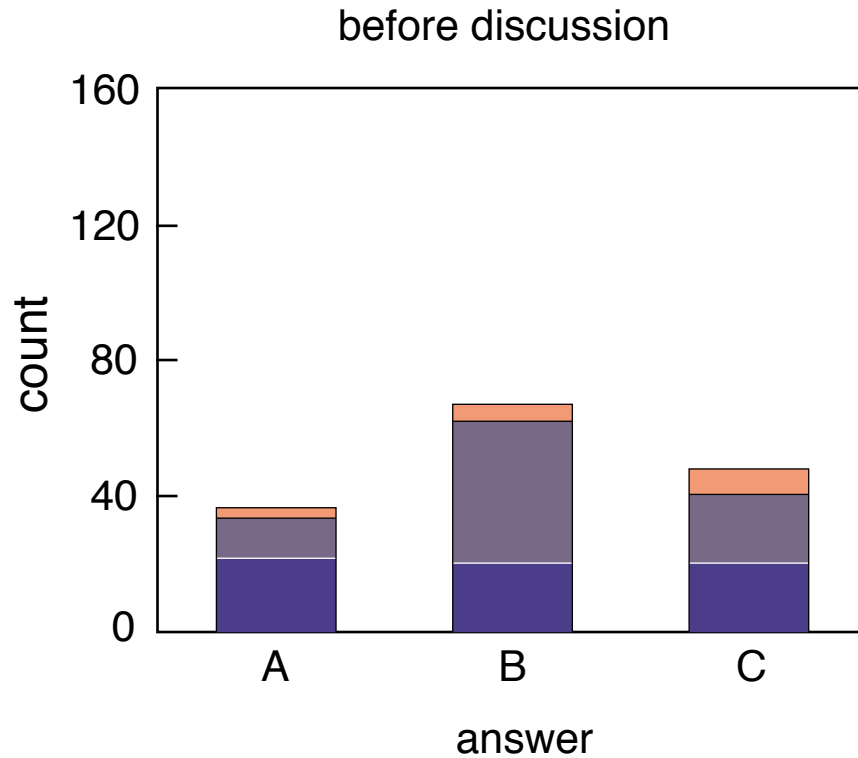
15. While the car, still pushing the truck, is speeding up to get up to cruising speed,
- ___ 1. the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
 - ___ 2. the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
 - ___ 3. the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.
 - ___ 4. the car's engine is running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.
 - ___ 5. neither the car nor the truck exerts any force on the other. The truck is pushed forward simply because it is in the way of the car.
16. After the car reaches the constant cruising speed at which its driver wishes to push the truck,
- ___ 1. the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
 - ___ 2. the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
 - ___ 3. the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.
 - ___ 4. the car's engine is running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.
 - ___ 5. neither the car nor the truck exerts any force on the other. The truck is pushed forward simply because it is in the way of the car.

Research: providing the basis for change

**Evaluate assessment by comparing
student performance on various kinds of problems**

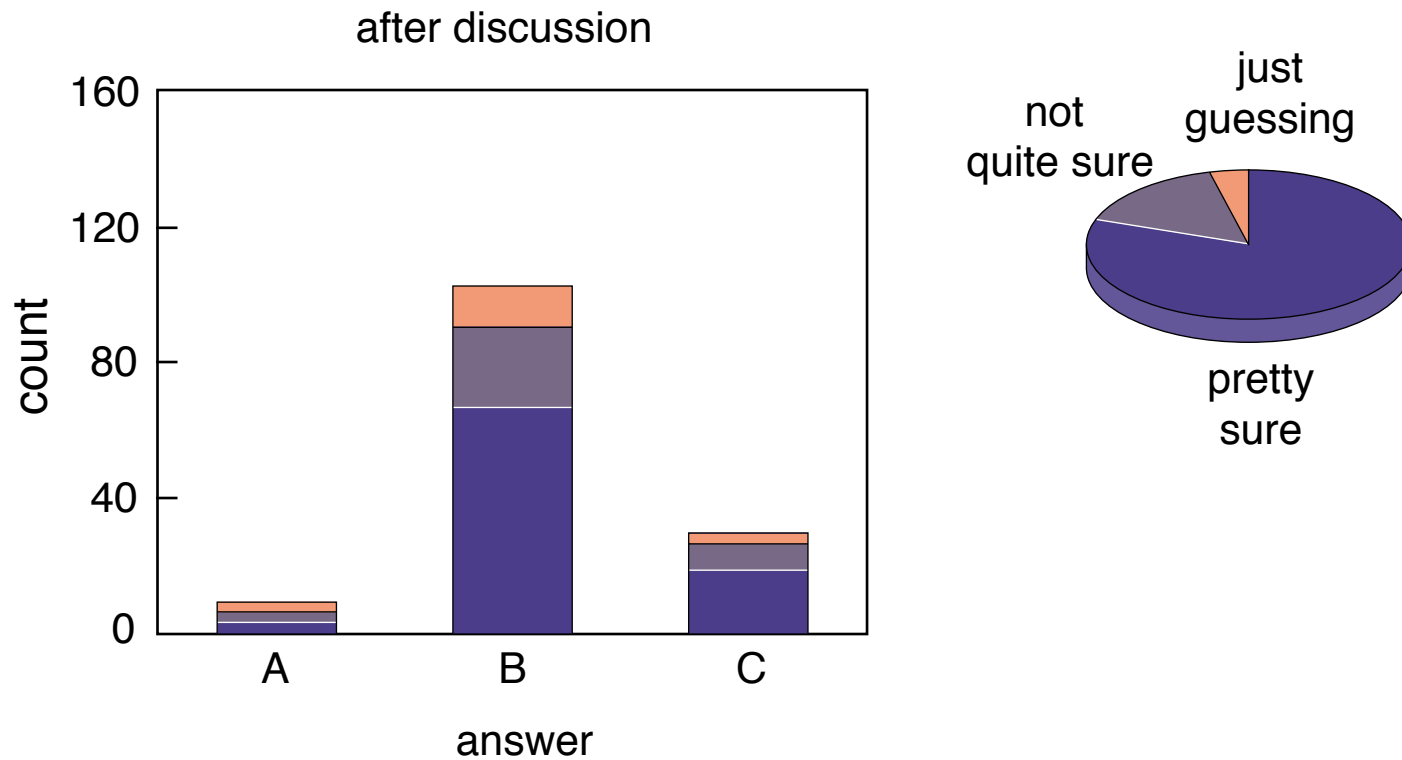
Research: providing the basis for change

ConceptTest data



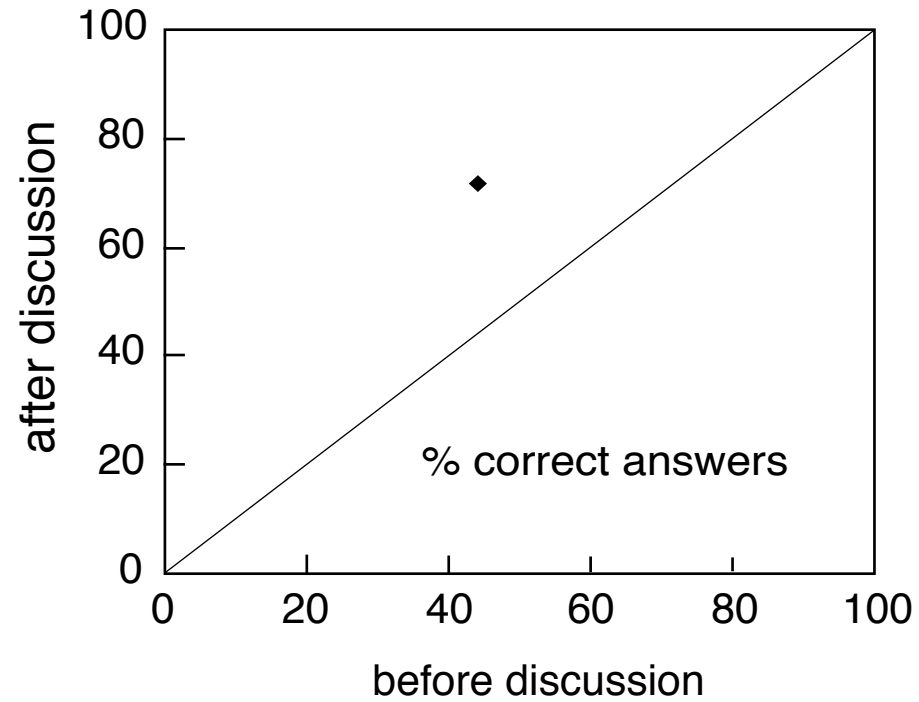
Research: providing the basis for change

ConceptTest data



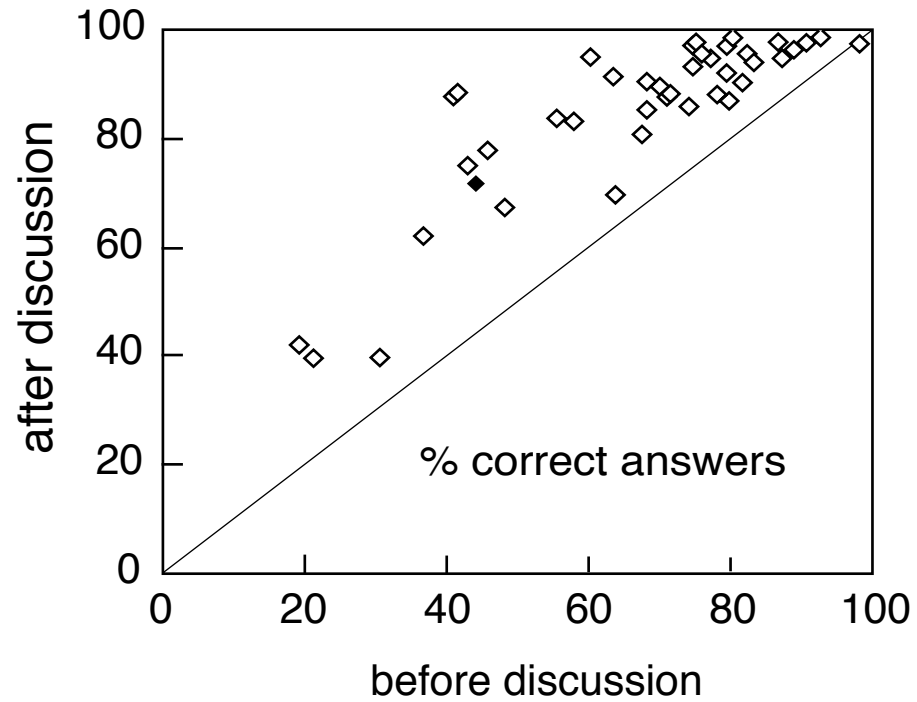
Research: providing the basis for change

ConceptTest data



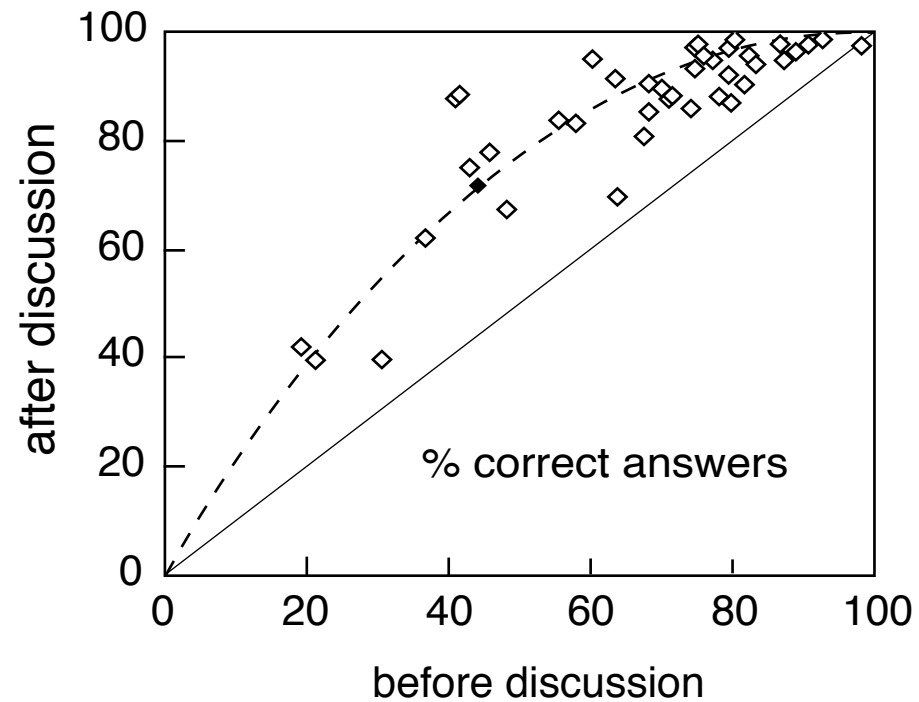
Research: providing the basis for change

ConceptTest data



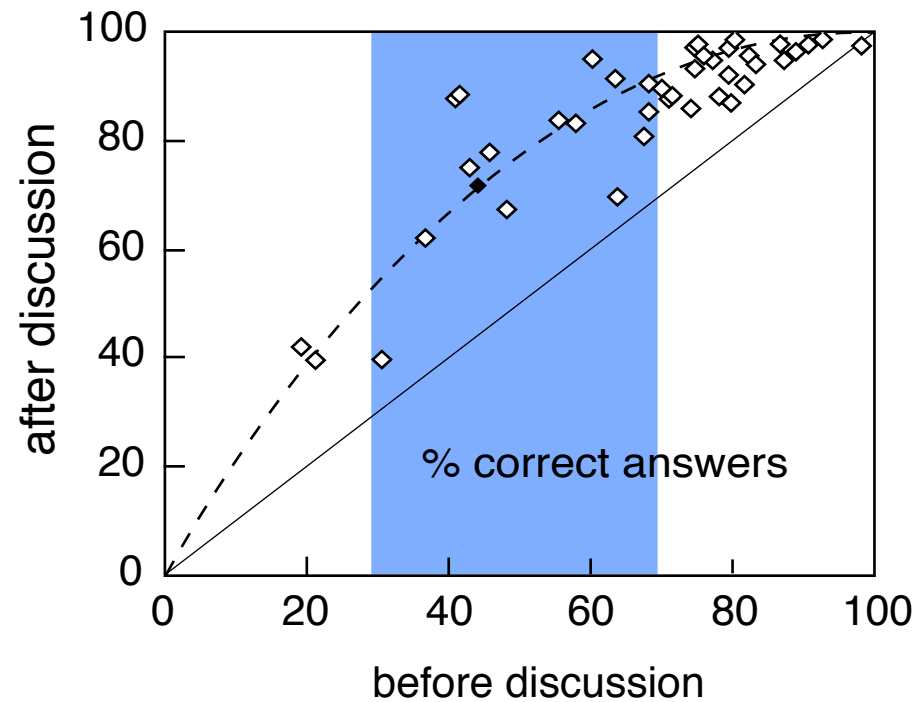
Research: providing the basis for change

ConceptTest data



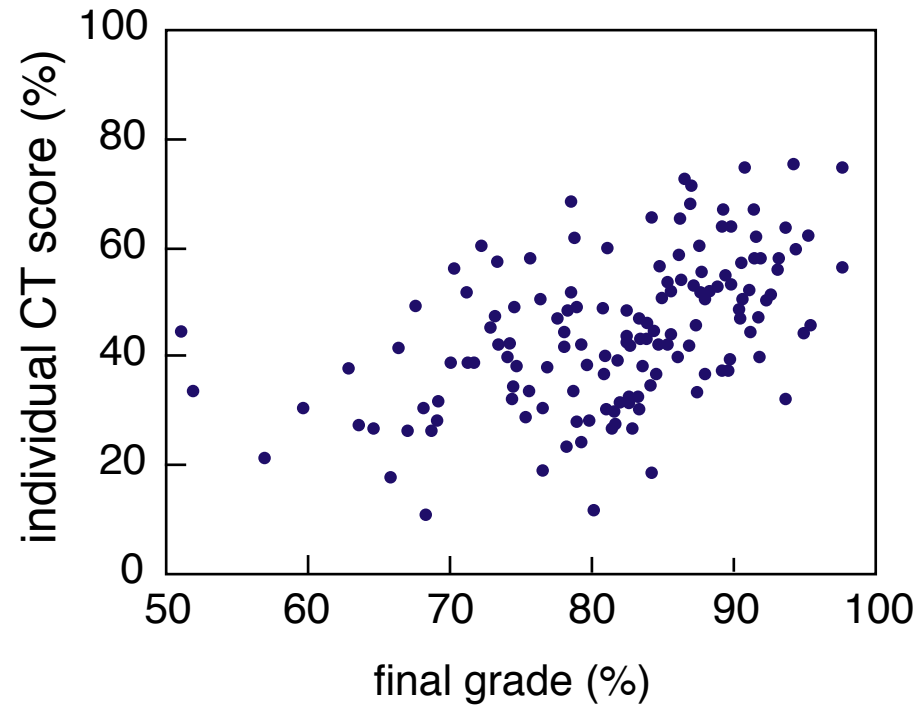
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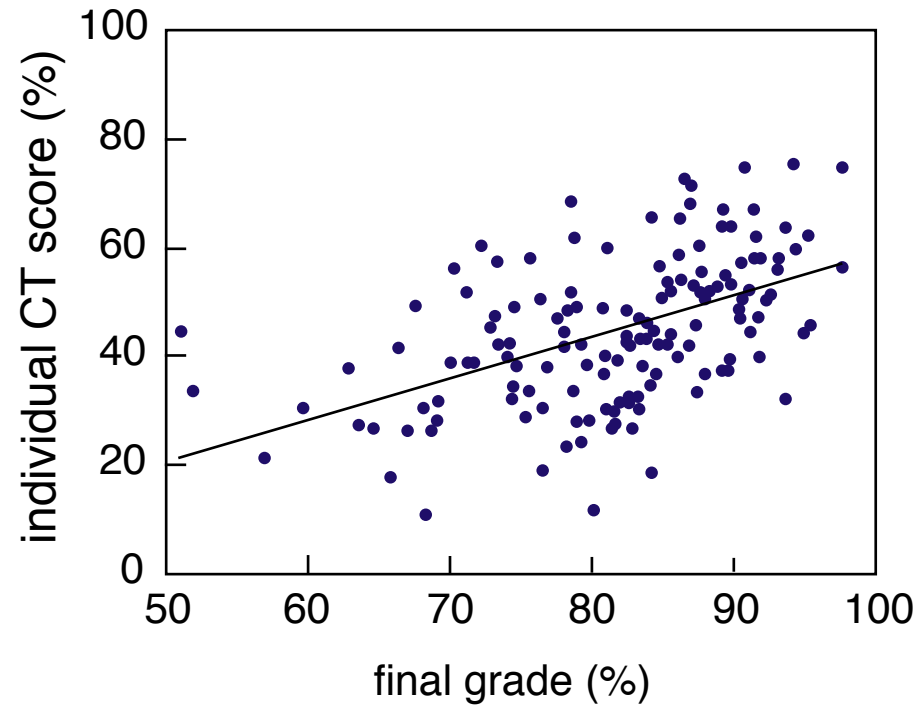
Research: providing the basis for change

who benefits from the ConcepTests?



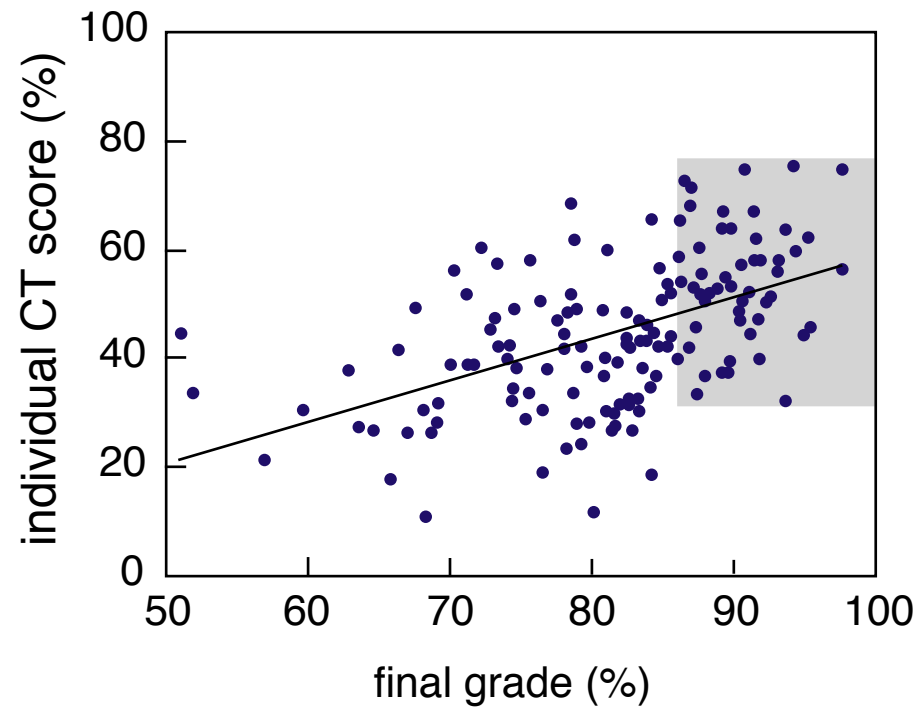
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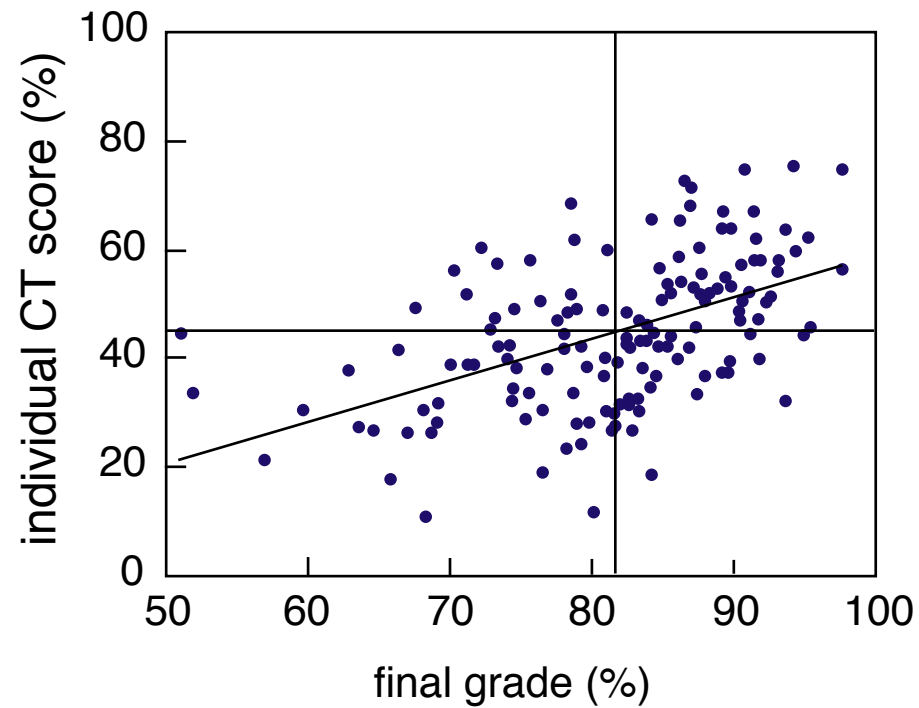
Research: providing the basis for change

even the best students are challenged



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Problems with problems

On a Saturday afternoon, you pull into a parking lot with unmeasured spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.

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Requires:

Assumptions

Developing a model

Applying that model

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Requires:

Applying a (new) model

Problems with problems

On a Saturday afternoon, you pull into a parking lot with unmeasured spaces near a shopping area, where people are known to shop, on average, for 2 hours. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.

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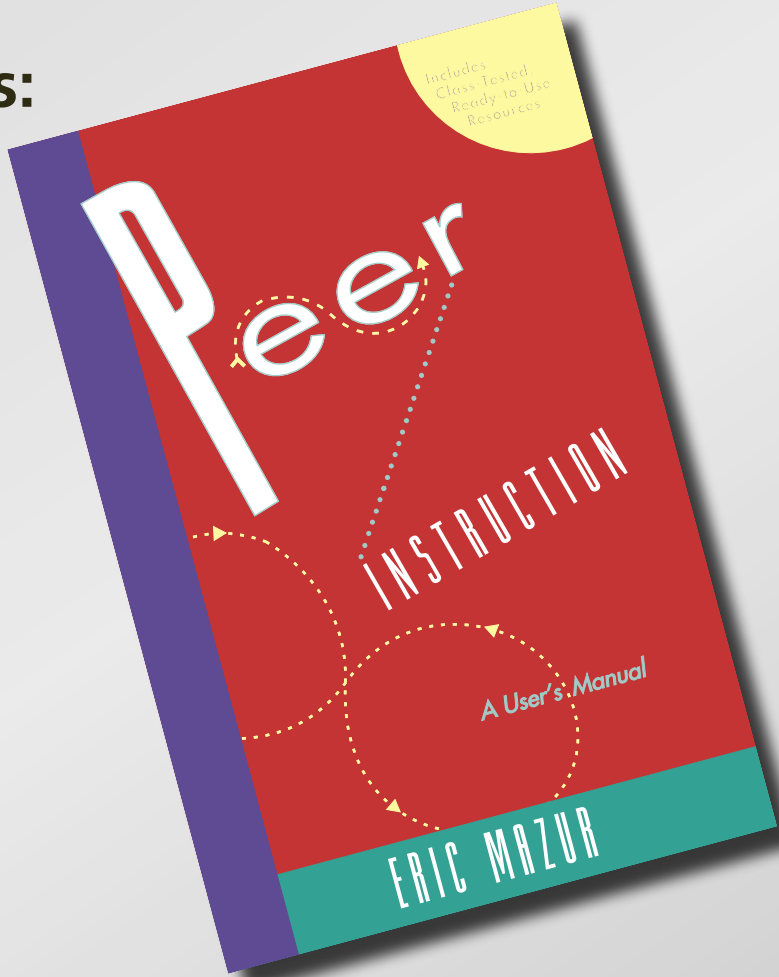
Using a calculator

$$t_{wait} = \frac{T_{shop}}{N_{spaces}}$$

Resources

Books with ConcepTests:

- Physics (Prentice Hall)



Resources

Books with ConcepTests:

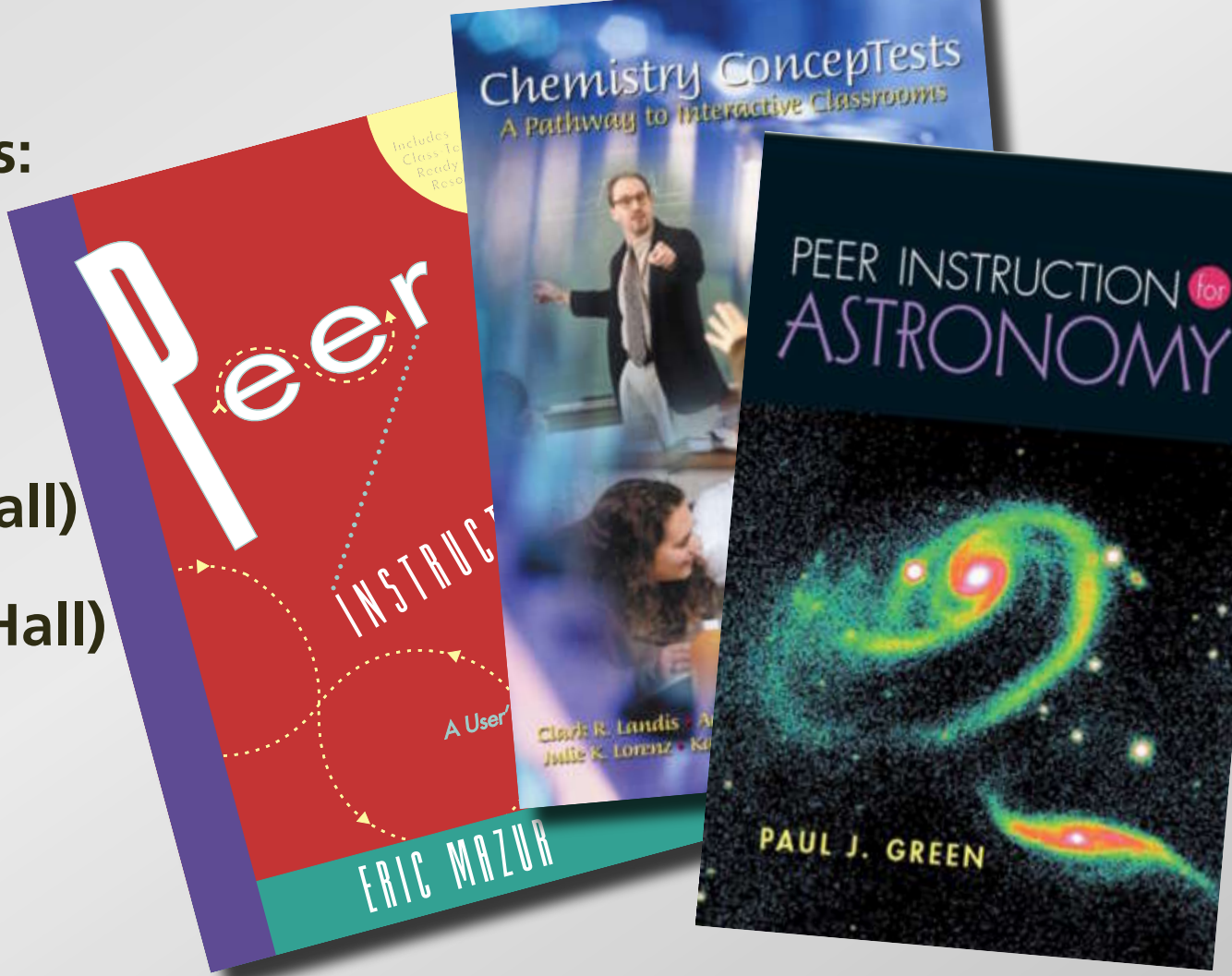
- Physics (Prentice Hall)
- Chemistry (Prentice Hall)



Resources

Books with ConcepTests:

- Physics (Prentice Hall)
- Chemistry (Prentice Hall)
- Astronomy (Prentice Hall)



Resources

Books with ConcepTests:

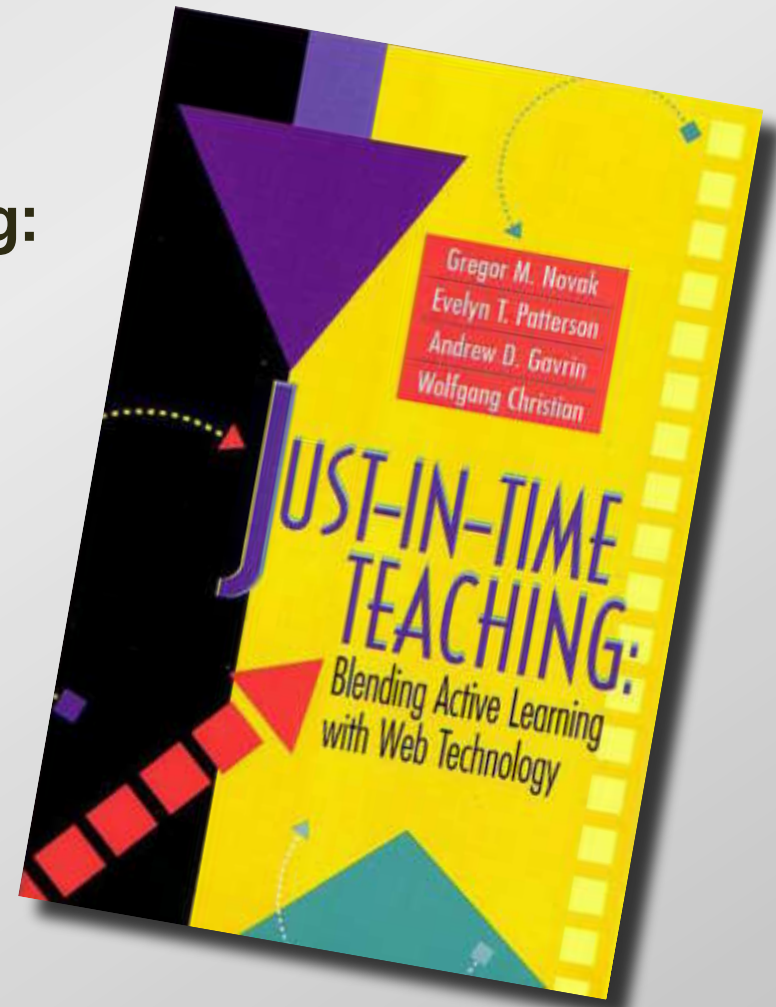
- Physics (Prentice Hall)
- Chemistry (Prentice Hall)
- Astronomy (Prentice Hall)
- Calculus (Wiley)



Resources

Information on Just-in-Time-Teaching:

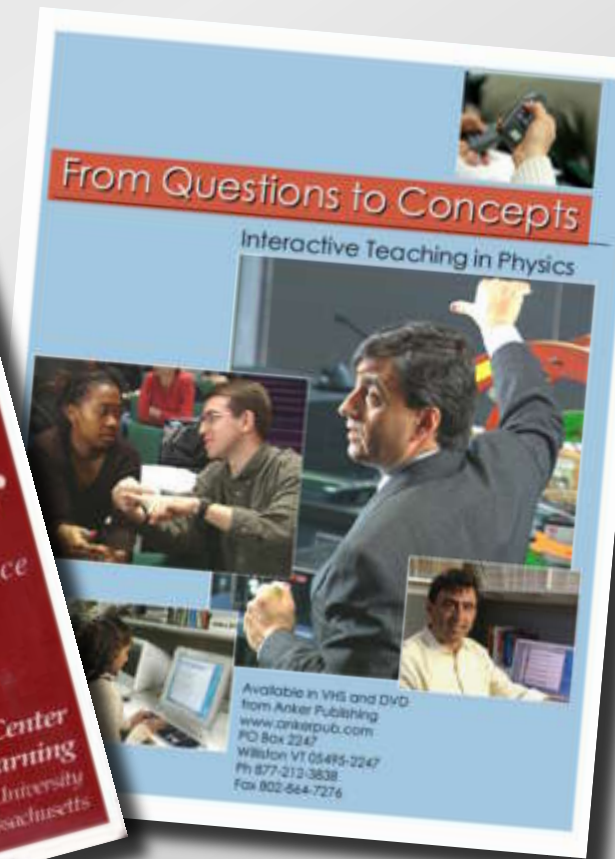
- Prentice Hall book
- <http://www.jitt.org>



Resources

Videos:

- Thinking together
- From questions to concepts



<http://www.ankerpub.com>

Resources

Course management:

<http://deas.harvard.edu/ilt>

The screenshot shows a web browser window titled "ILT: Manage" with the URL "http://www.conceptest.org". The page is for "Physics 1b" and has a navigation menu with links for HOME, READING, LECTURES, ASSIGNMENTS, FORUMS, NEWS, and HANDOUTS. The user is logged in as "Eric Mazur".

The main content area displays a physics problem titled "Changing magnetic fields 8.4B". The problem text is: "1. A permanent magnet is dropped through a long aluminum tube, as shown. As the magnet drops, electric currents are induced around the tube. Compared to a freely-falling magnet, the magnet through the tube drops".

Below the text are two diagrams of a cylindrical aluminum tube. The left diagram shows a magnet with a downward-pointing arrow labeled "B" above it, indicating the direction of the magnetic field. The right diagram shows the magnet inside the tube, with a dashed line representing the path of the magnet.

Below the diagrams are four multiple-choice options:

1. more slowly.
2. exactly the same way.
3. faster.
4. Need more information.

A "Hint" is provided: "Hint: consider the effects of induced currents through strips ahead of and behind the dropped magnet." An "Answer" is also provided: "Answer: 1. In a loop of the aluminum tube just below the magnet, the flux is increasing as the magnet gets nearer. This induces a counterclockwise current producing an opposing magnetic field which repels the magnet. In a loop above the magnet, the flux is decreasing, so a clockwise current is induced, producing a magnetic field in the same direction as the magnet's field, thus attracting the magnet upward. So the net effect is to slow the magnet down." The page is copyrighted © 2000, Eric Mazur, and is marked as unpublished copyrighted material.

The bottom of the page shows another problem titled "Physics > Introductory Electromagnetism > Magnetism > CT: 3756" with the text: "2. Consider the arrangement shown below. Conducting rod AB is lying on a U-shaped conductor, making good electrical contact. The arrangement is placed in a magnetic field (into page)." Below this text is a diagram of a U-shaped conductor with a rod AB across it, and a magnetic field symbol "A" with a downward-pointing arrow.

Barriers to reform

Challenges:

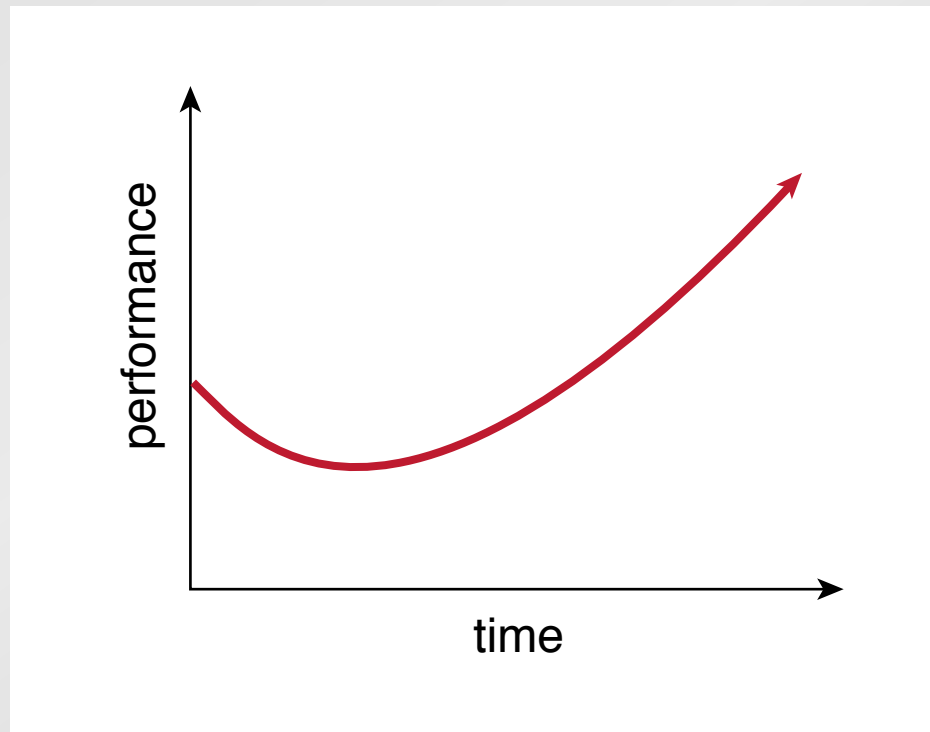
- **skepticism**
- **growing pains**
- **limited circle of influence**

Barriers to reform

Two things to watch out for

Barriers to reform

After changing, things might get *worse* before they get better!



Barriers to reform

Better understanding leads to *more* — not fewer — questions!

(must recognize confusion as step towards understanding)

Barriers to reform

Things to do:

- **take data**
- **motivate students**
- **be prepared for initial adjustments**

Funding:

National Science Foundation

for a copy of this presentation:

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