

# **MEMORIZATION OR UNDERSTANDING: ARE WE TEACHING THE RIGHT THING?**

**Eric Mazur**

**University of Victoria  
19 May 1999**



# *Outline*

▶ **Problem**

# *Outline*

▶ **Problem**

▶ **Cause**

# *Outline*

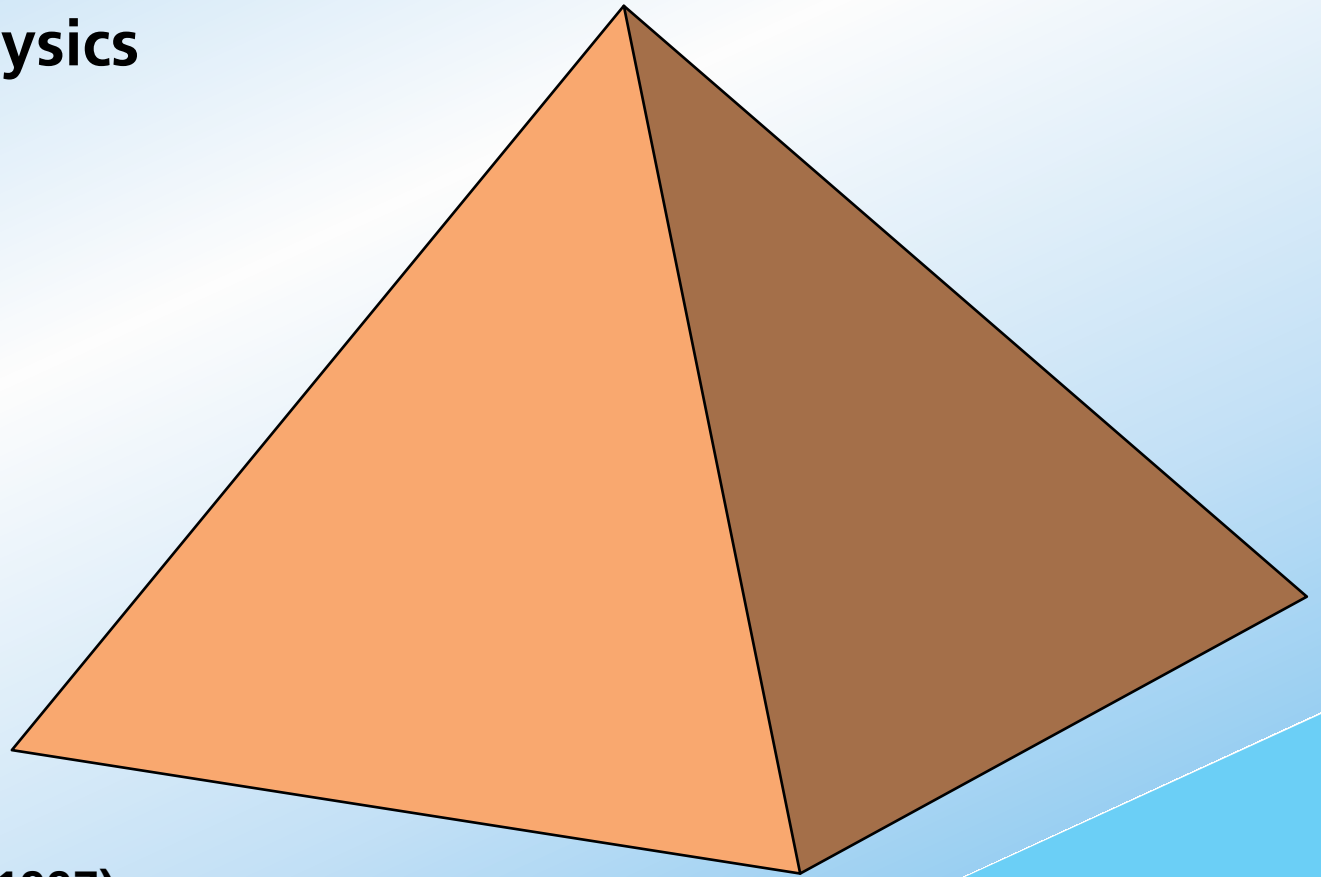
▶ **Problem**

▶ **Cause**

▶ **Remedy**

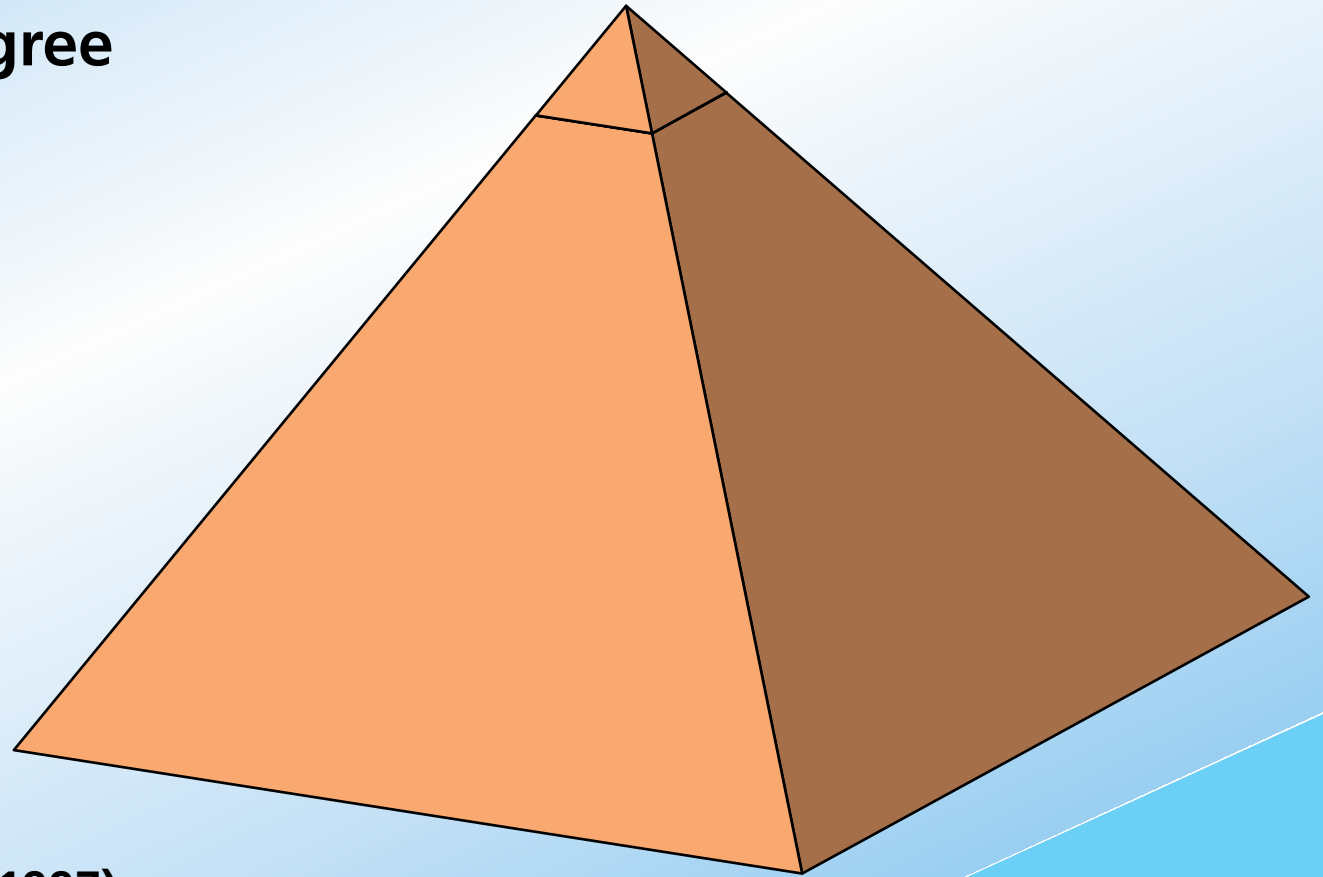
# *We have a problem*

**380,000 students take  
introductory physics  
each year...**



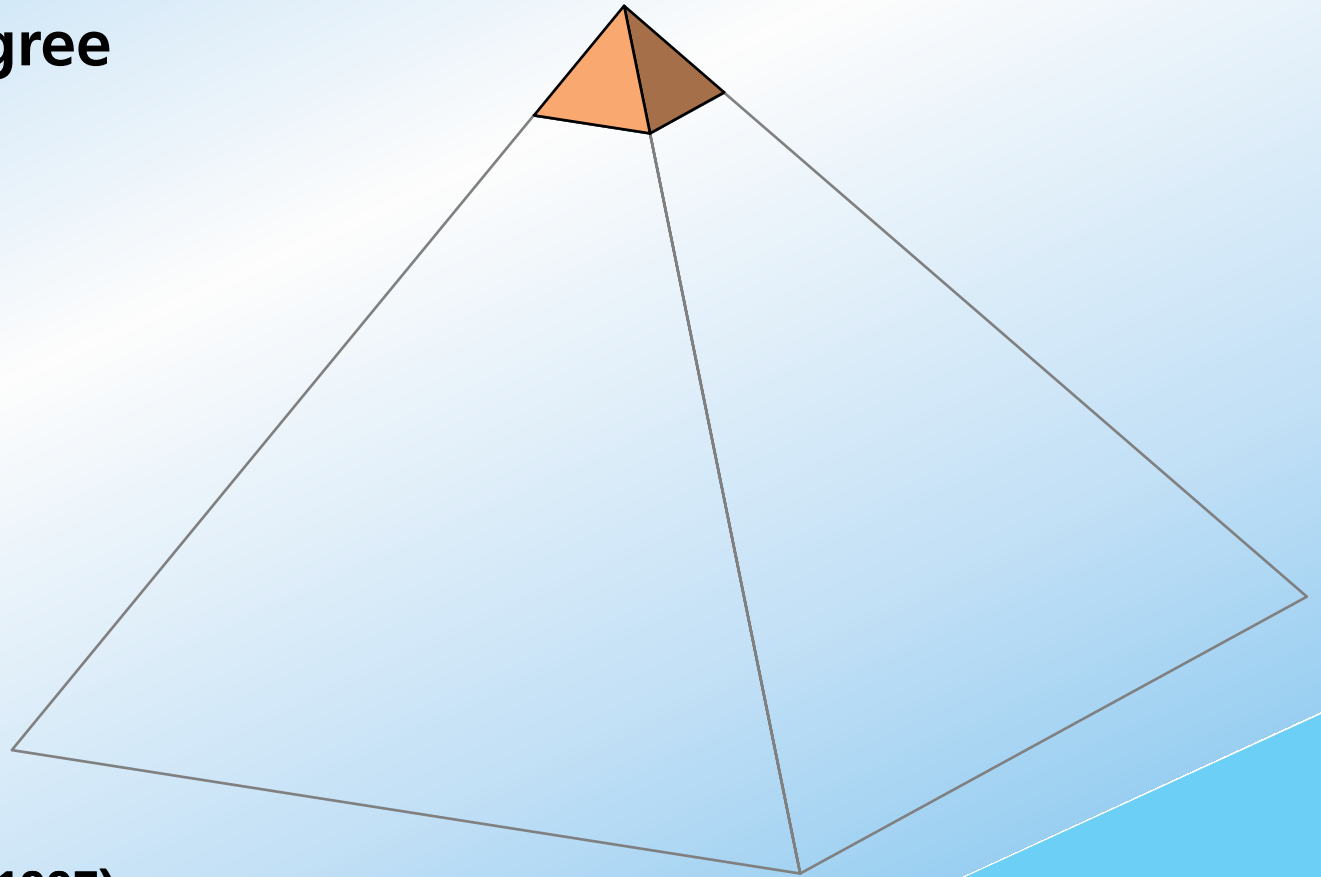
# *We have a problem*

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



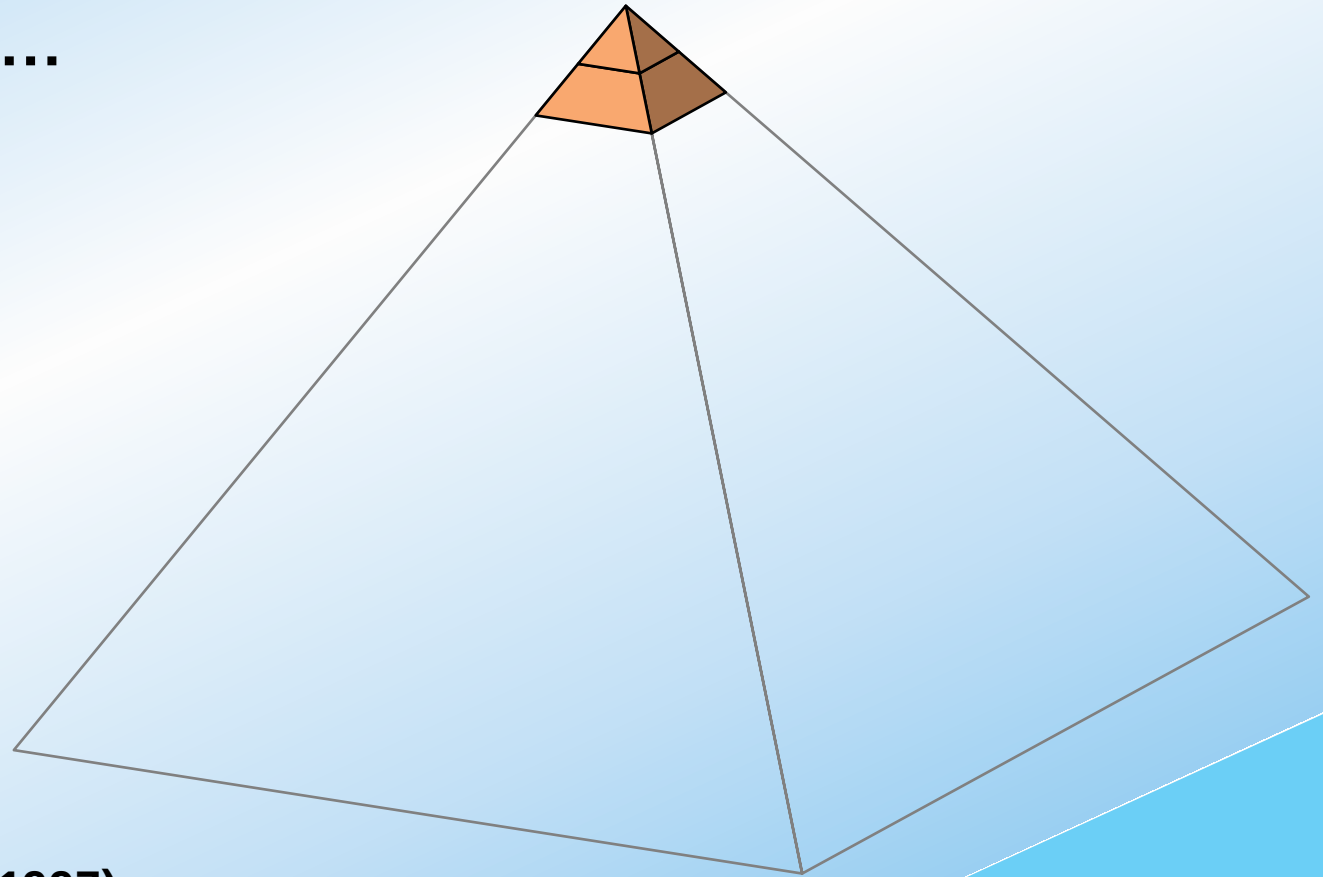
# *We have a problem*

**Of the 4,300 students with  
a bachelor's degree  
in physics...**



# *We have a problem*

**about 35% go on to get a  
Ph.D. in physics...**

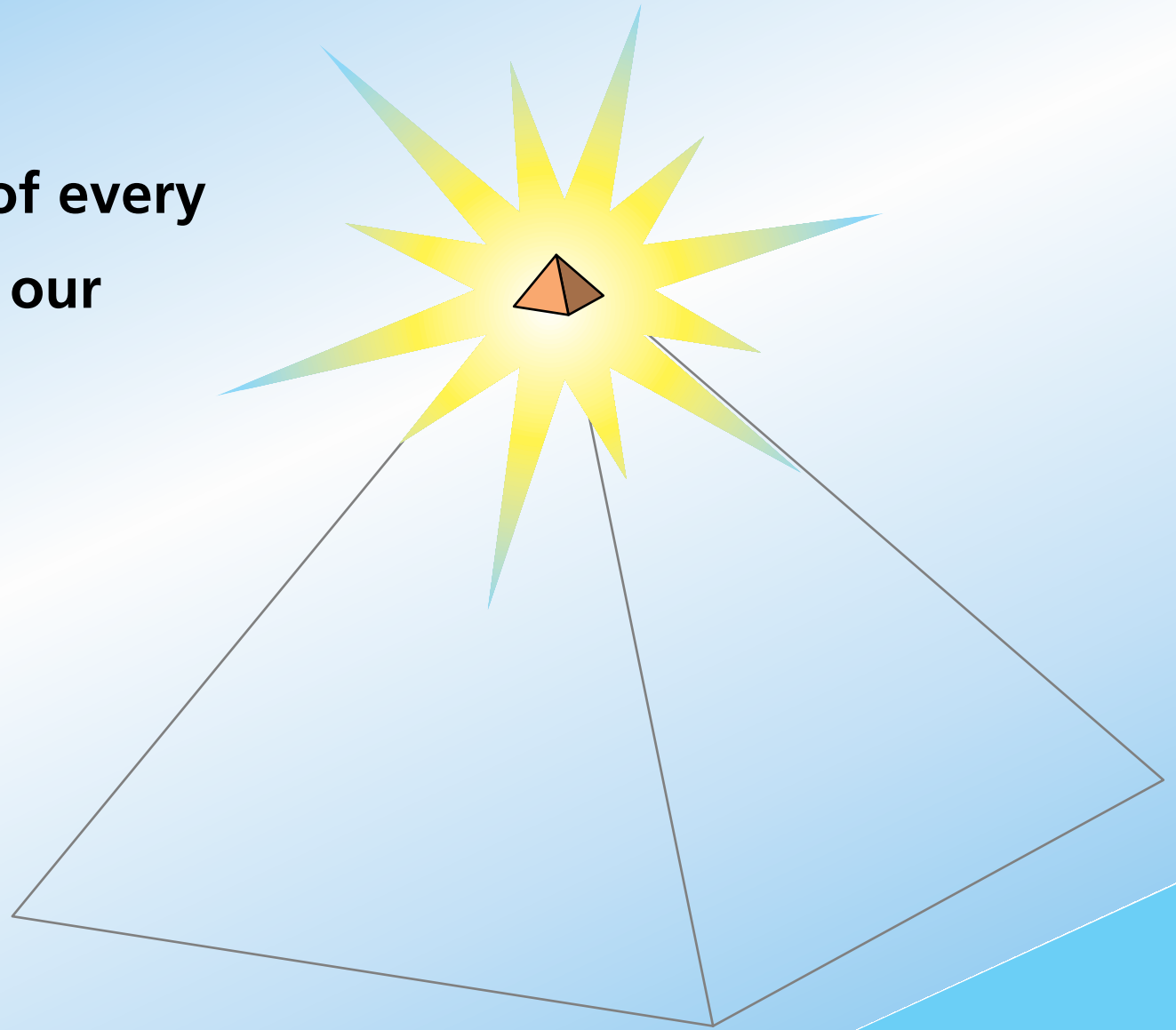


***AIP Report R-151.33 (1997)***



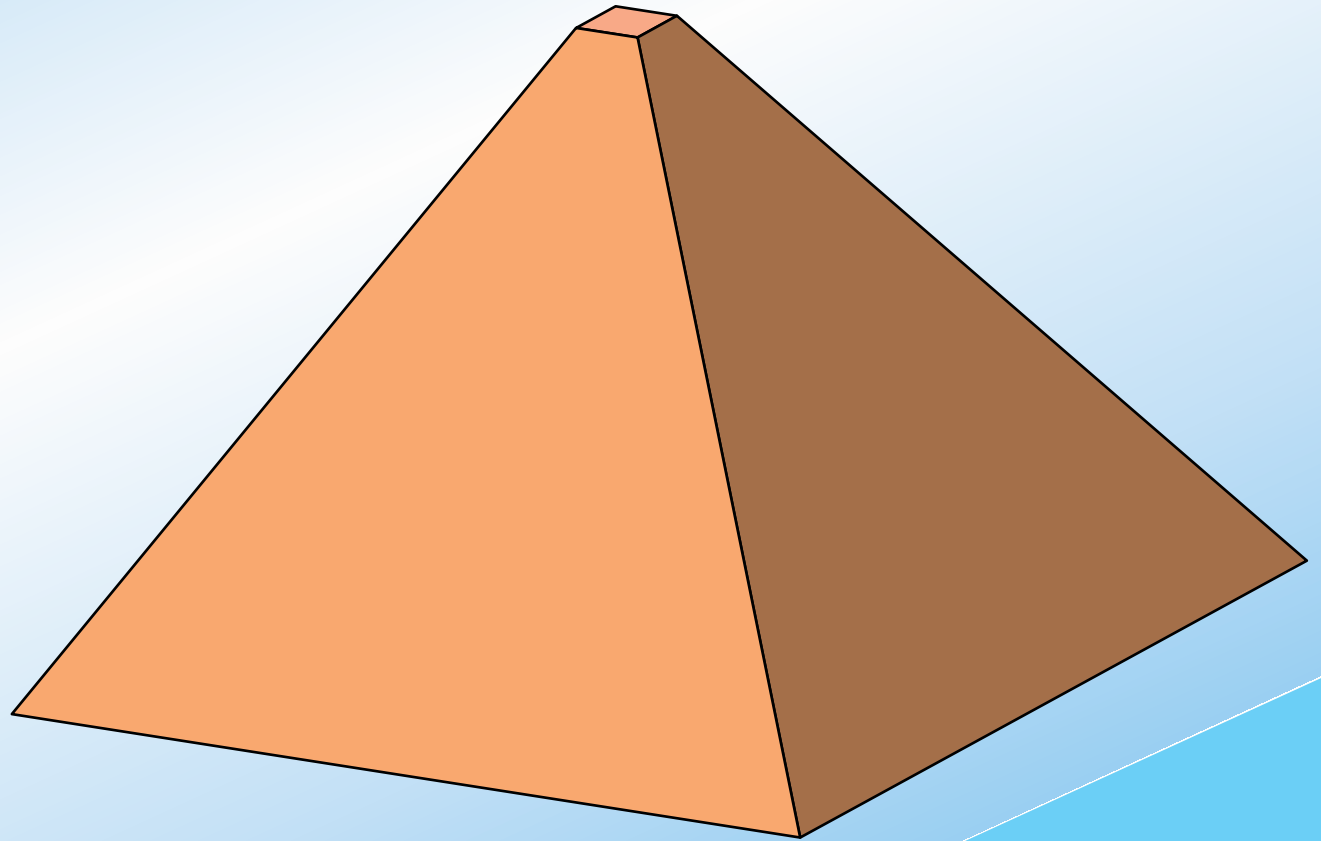
# *We have a problem*

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



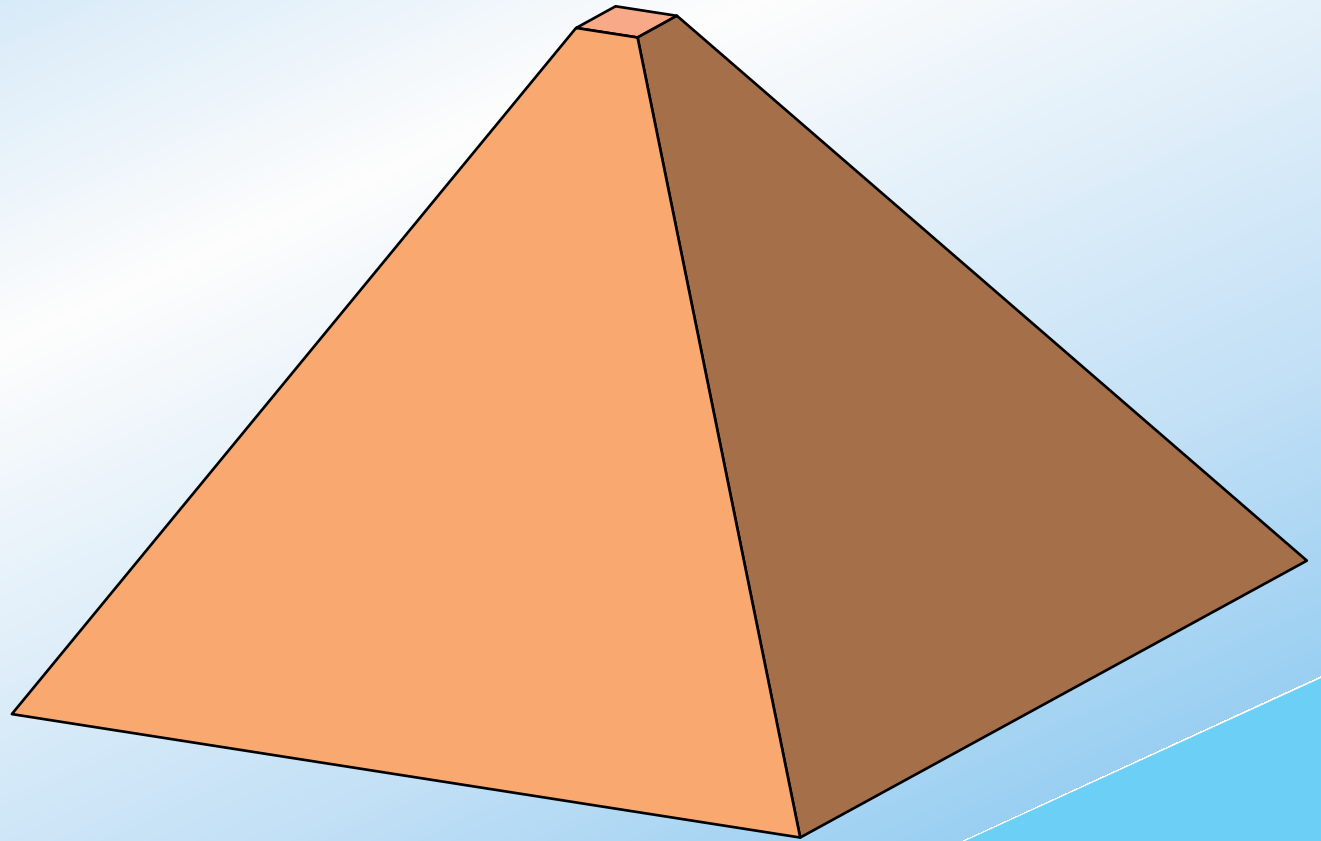
# *We have a problem*

**What about the  
other 259...?**



# *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*

Well, “hot” is a relative term...

You see, given temperatures rise, regardless of mass.

Yeah, Galileo observed rising temperatures will decrease with the exposure of an endothermic source.

Endothermic?

True transience will persist until this one irresistible calorie interacts, thus altering the system.

## *We have a problem*

Well, “hot” is a relative term...

You see, given temperatures rise, regardless of mass.

Yeah, Galileo observed rising temperatures will decrease with the exposure of an endothermic source.

Endothermic?

True transperence will persist until this one irresistible calorie interacts, thus altering the system.

Uh huh...





# *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?*"**



A close-up photograph of a diverse group of young people, likely students, smiling and looking towards the left. The image has a slightly desaturated, warm tone. The text "Why do we have this problem?" is overlaid in the lower center of the image.

**Why do we have this problem?**

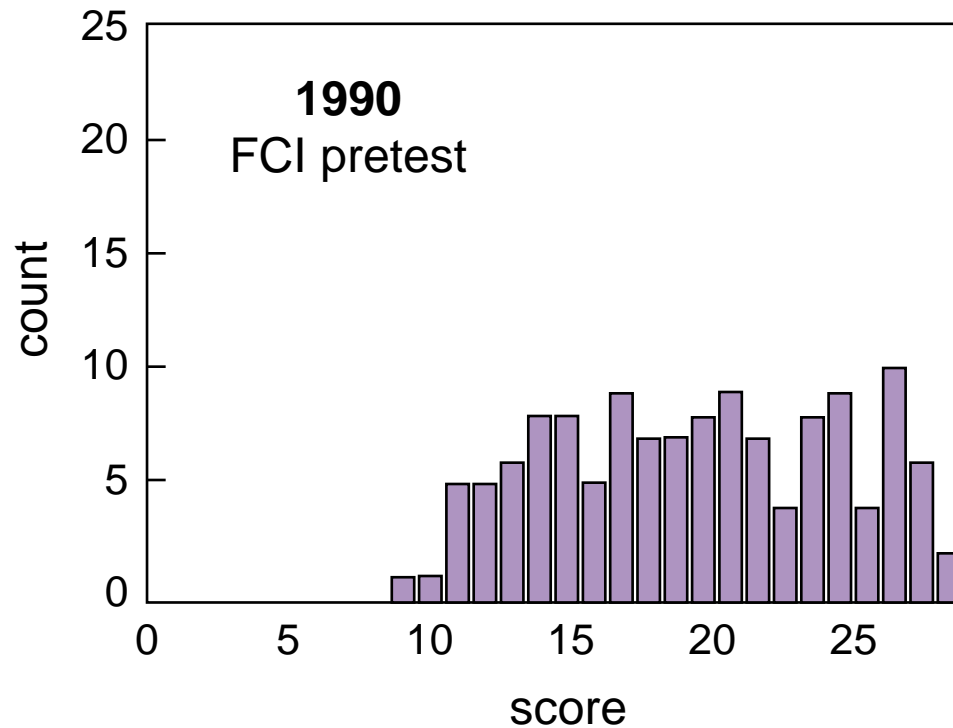


## *Why do we have this problem?*

**Lectures focus on transfer of information...**

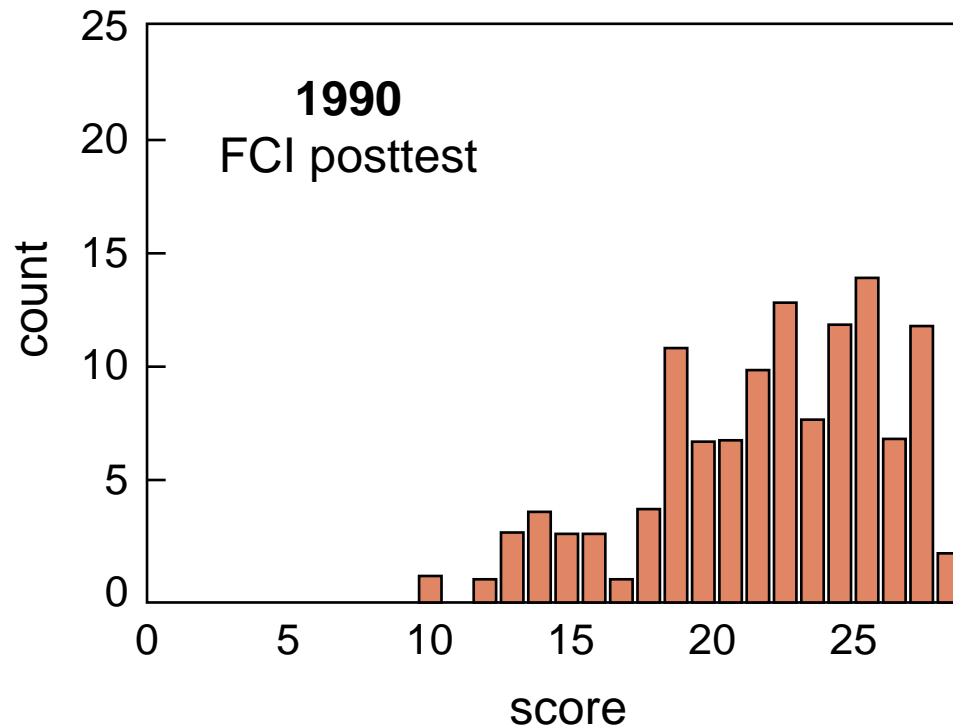
# *Why do we have this problem?*

...but physics is not just information!



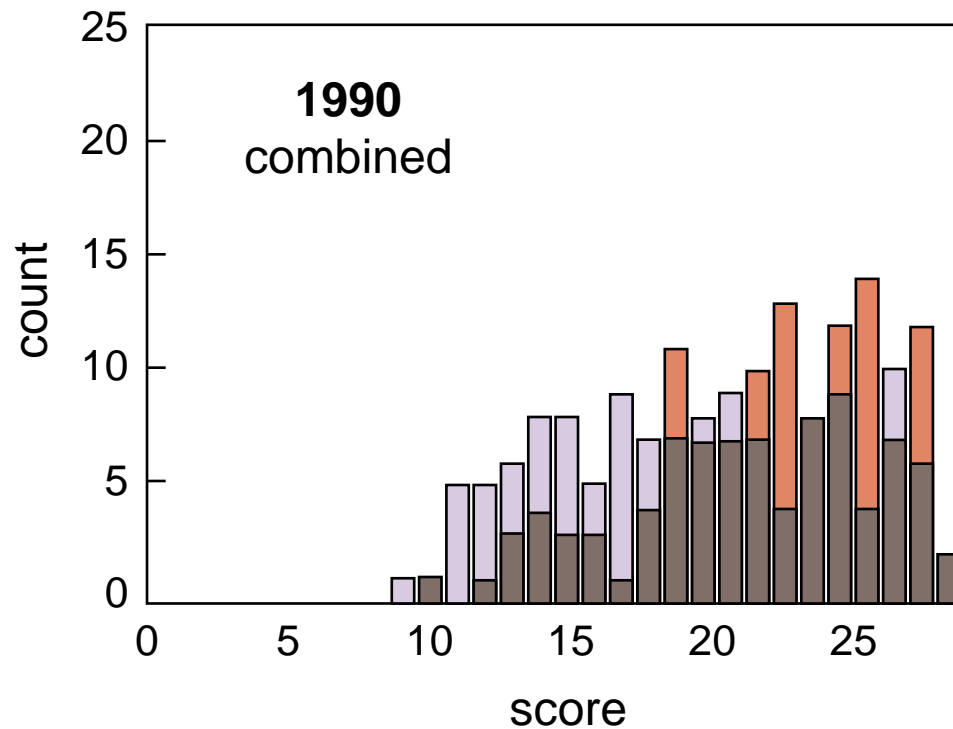
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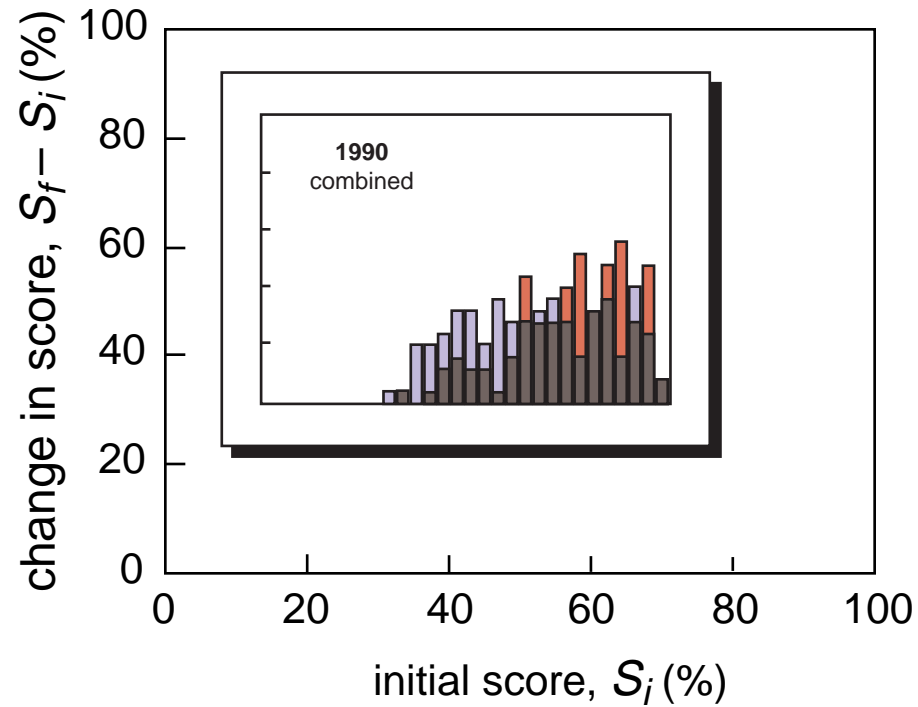


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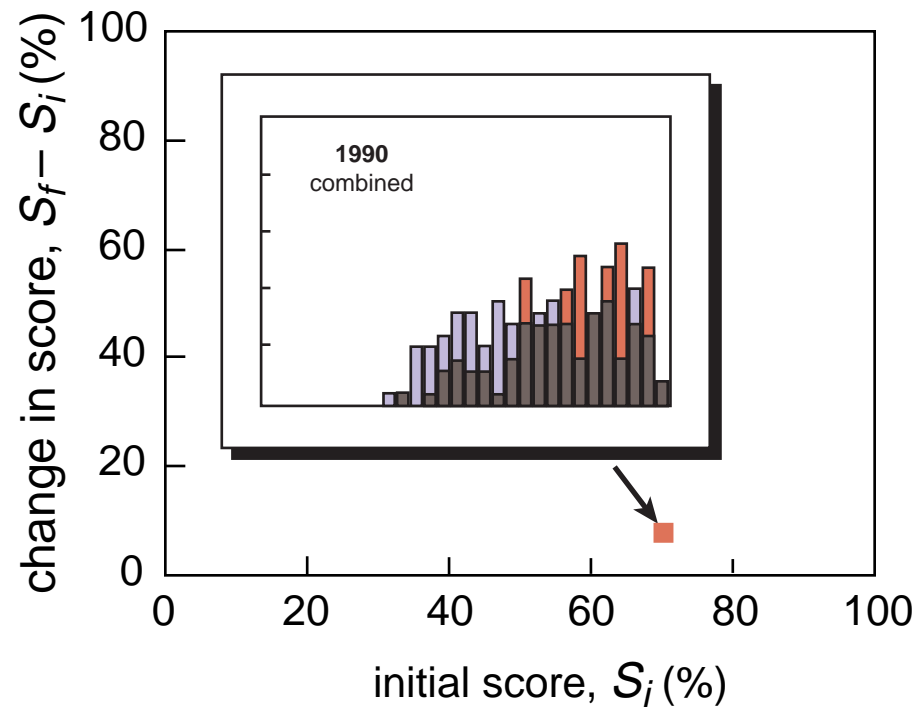
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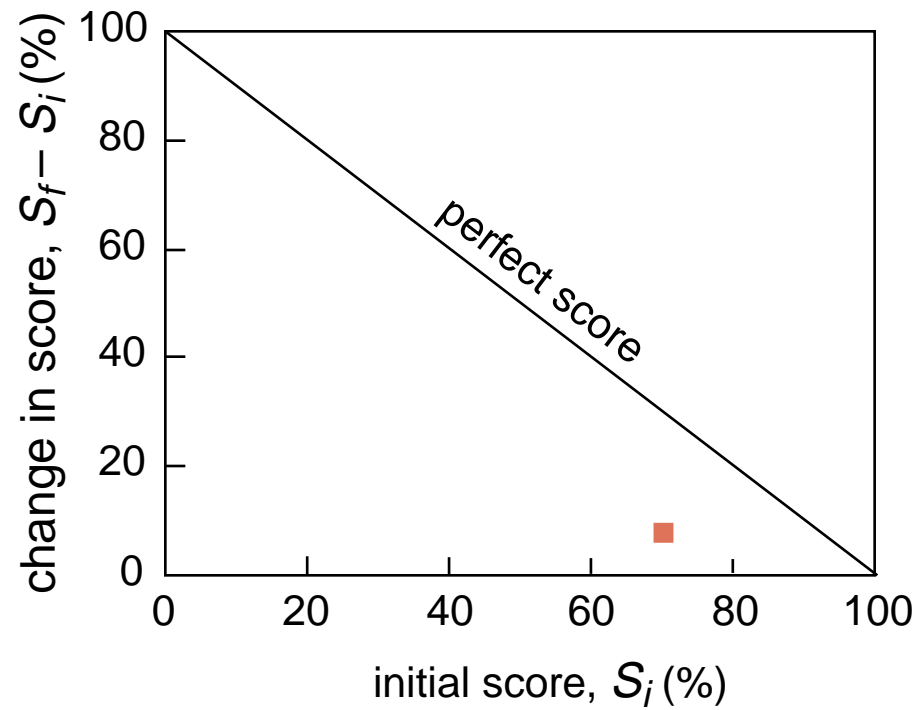
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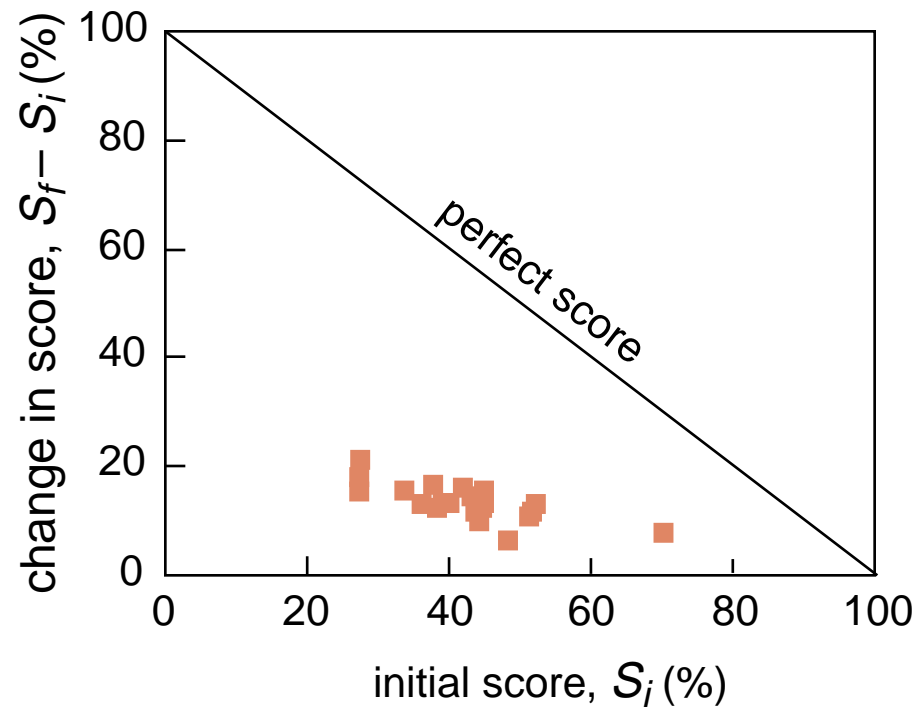
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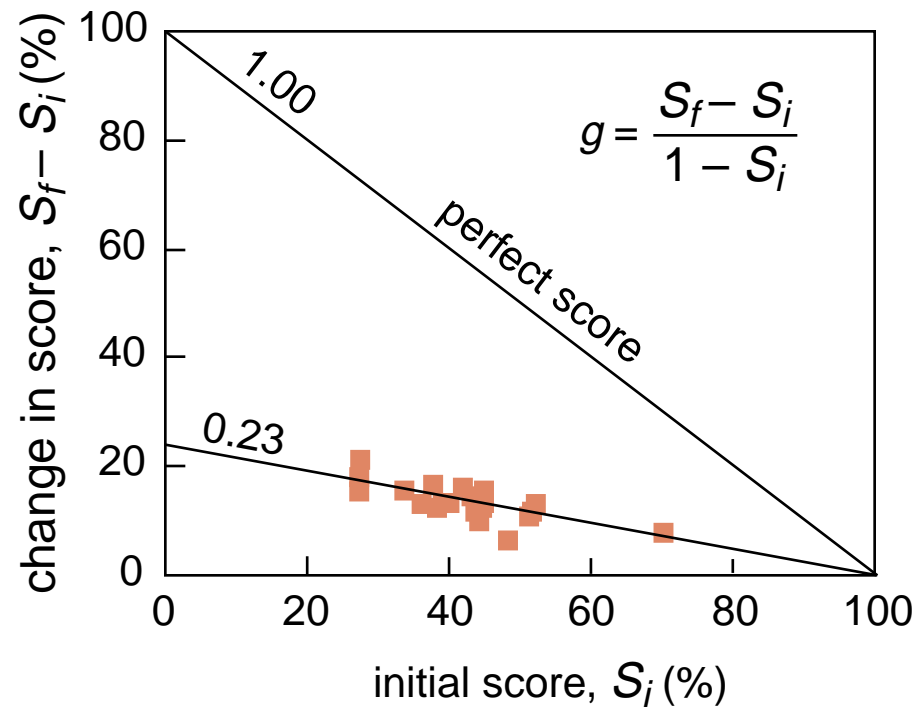


# Why do we have this problem?





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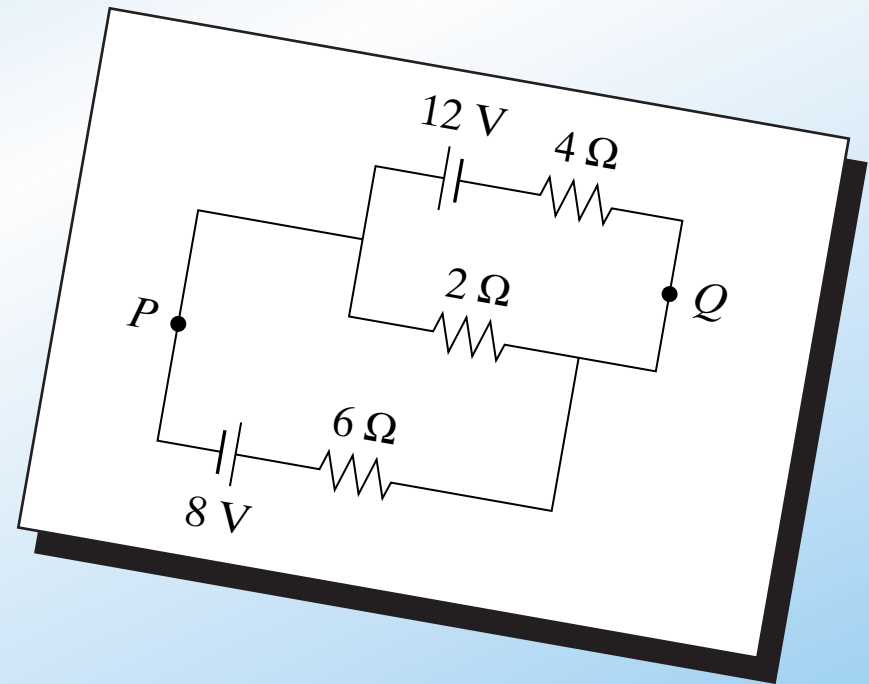


## *Why do we have this problem?*

**Conventional problems reinforce bad study habits**

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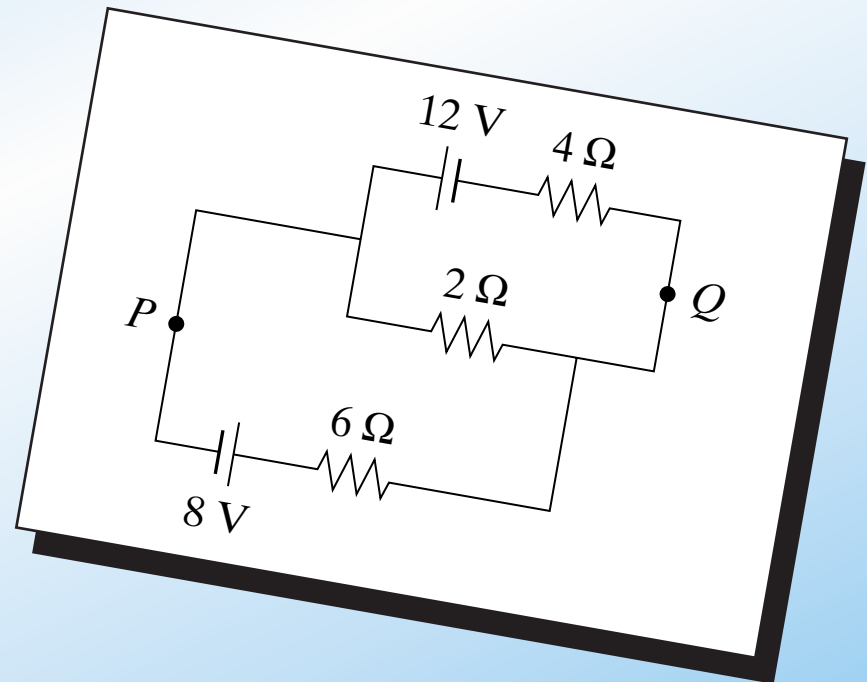


# Why do we have this problem?

## Conventional problems reinforce bad study habits

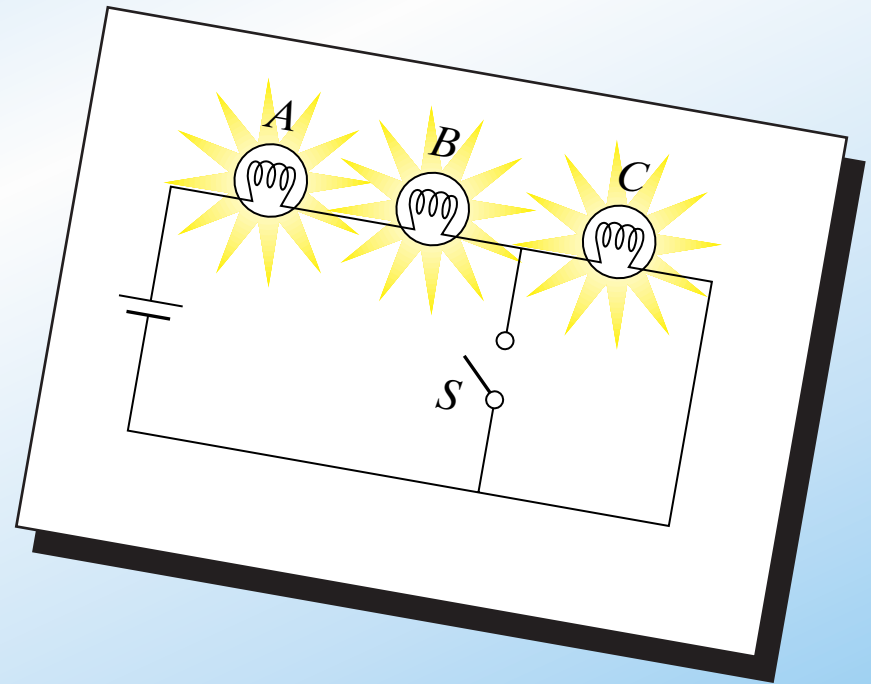
Calculate:

- (a) the current in the  $2\text{-}\Omega$  resistor, and
- (b) the potential difference between points  $P$  and  $Q$



*Why do we have this problem?*

**Are basic principles understood?**

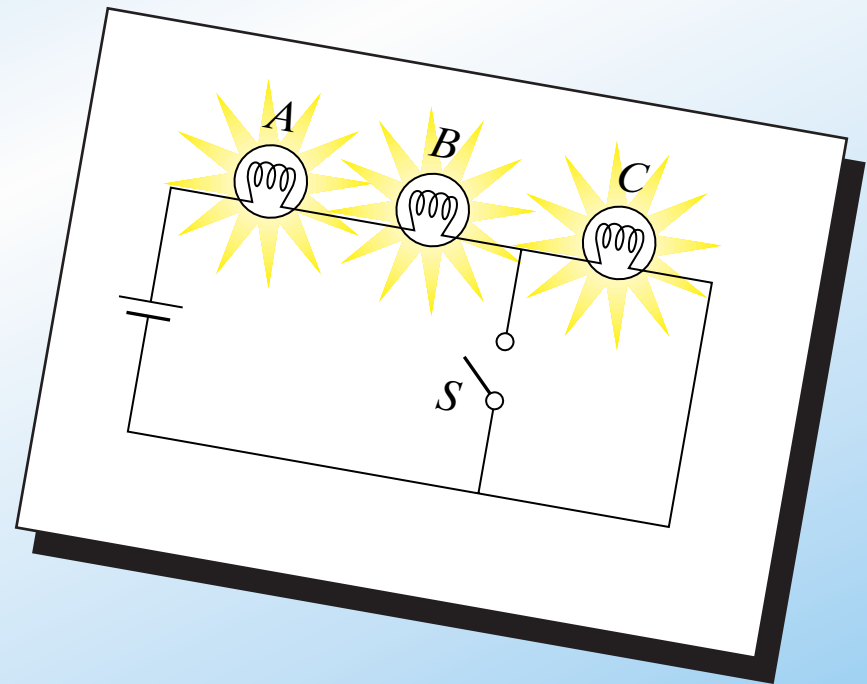


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## Are basic principles understood?

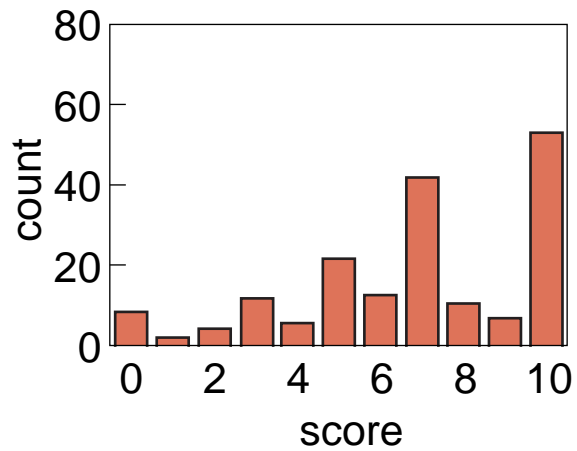
When  $S$  is closed, what happens to the:

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

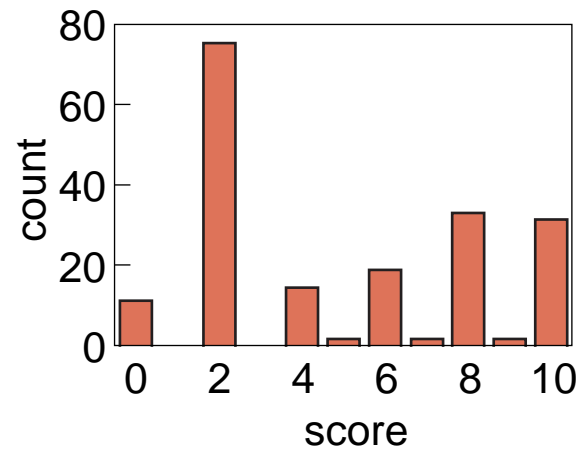


# Why do we have this problem?

## conventional

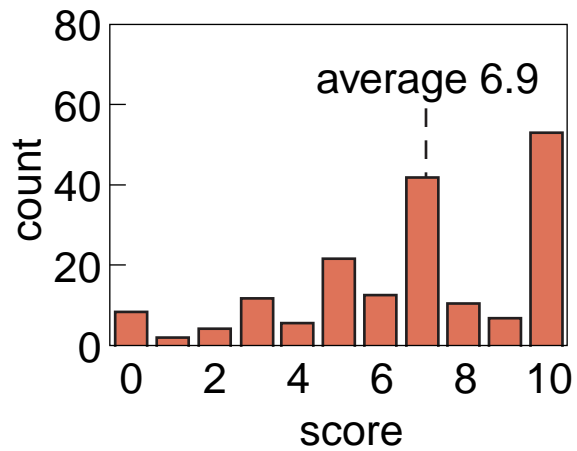


## conceptual

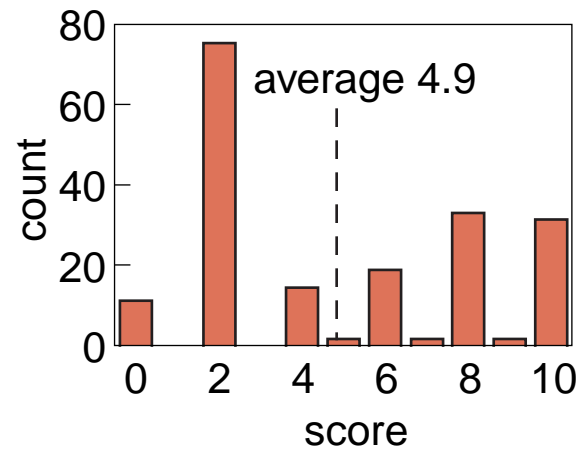


# Why do we have this problem?

conventional

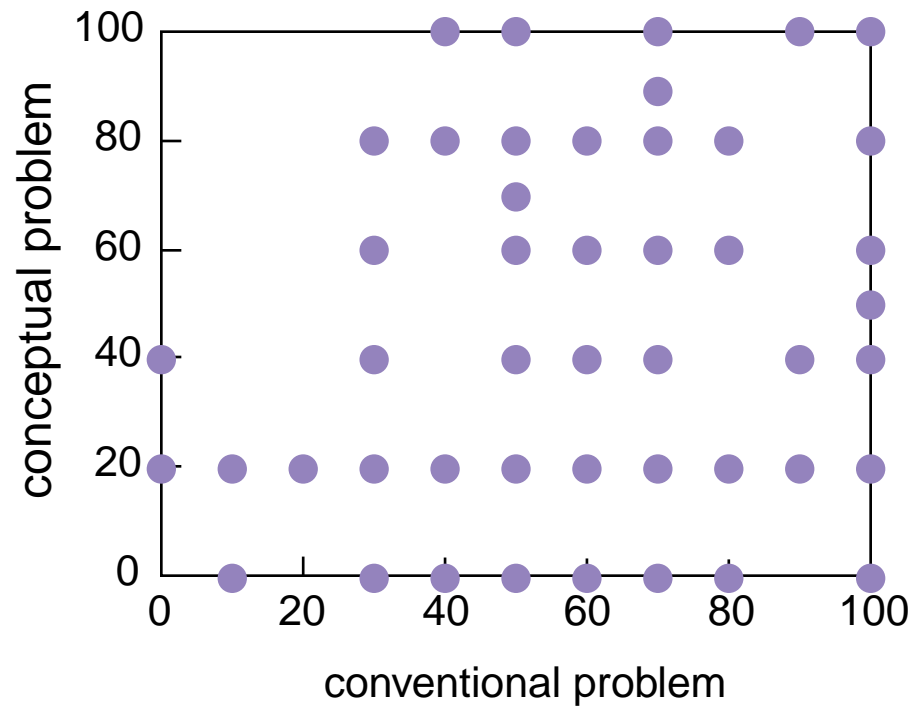


conceptual

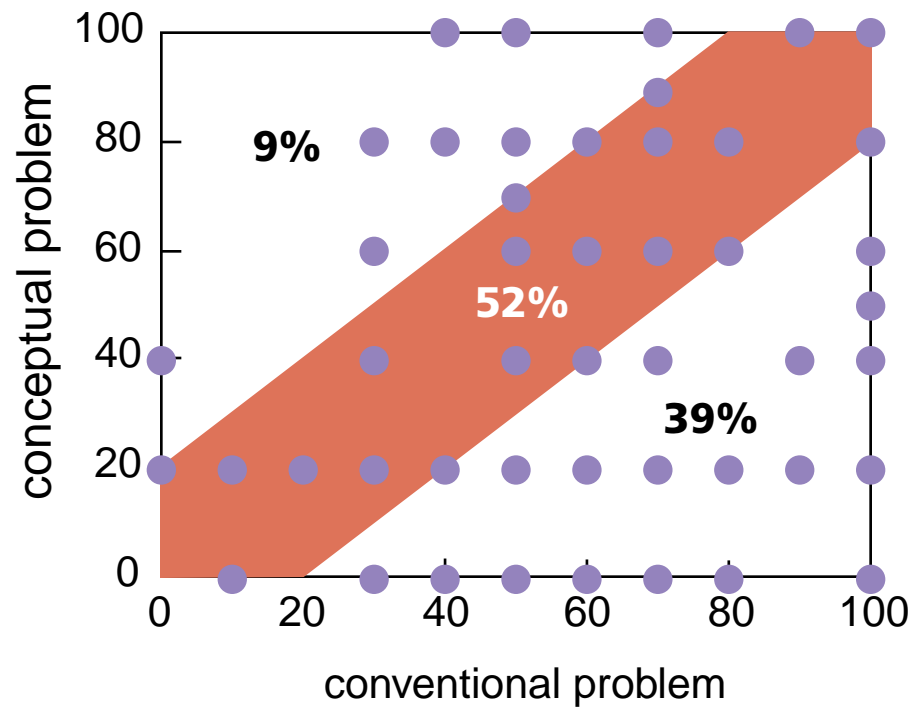




# Why do we have this problem?



# Why do we have this problem?



A wide-angle photograph of a large lecture hall. The room is filled with students seated at desks, facing a stage. On the stage, a lecturer is standing at a podium, and another person is visible further back. A large projection screen at the front of the room displays text and a diagram. The text on the screen includes the heading "What are the following..." followed by several bullet points. The text is somewhat blurry but appears to be a list of items. The overall atmosphere is that of a formal academic setting.

So what should we do?

# *Peer Instruction*

**Help students take more responsibility for learning!**

## *Peer Instruction*

- ▶ **Move first exposure to the material out of the classroom...**



## *Peer Instruction*

- ▶ **Move first exposure to the material out of the classroom: *assign reading!***

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- ▶ Move first exposure to the material out of the classroom: **assign reading!**
- ▶ Use class to deepen and broaden understanding
- ▶ by identifying **key ideas**



# *Peer Instruction*

- ▶ Move first exposure to the material out of the classroom: **assign reading!**
- ▶ Use class to deepen and broaden understanding
- ▶ by identifying **key ideas**
- ▶ and giving students opportunities to **think**

# *Peer Instruction*

## **Main features:**

- ▶ **Pre-class reading**

# *Peer Instruction*

## **Main features:**

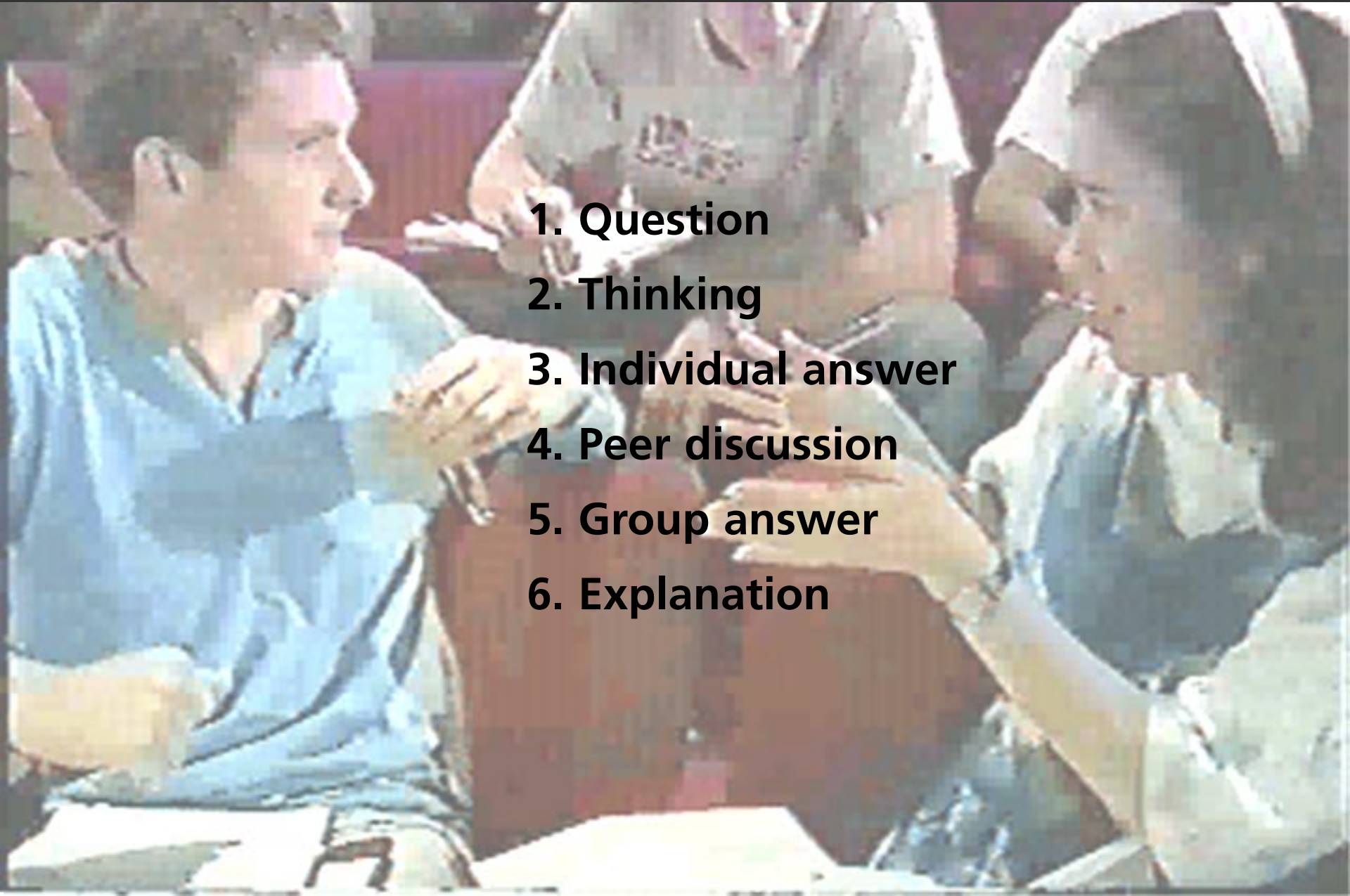
- ▶ **Pre-class reading**
- ▶ **In class: depth, not coverage**

# *Peer Instruction*

## **Main features:**

- ▶ **Pre-class reading**
- ▶ **In class: depth, not coverage**
- ▶ **ConcepTests**

## *ConcepTest*

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



*Is it any good?*

*Is it any good?*

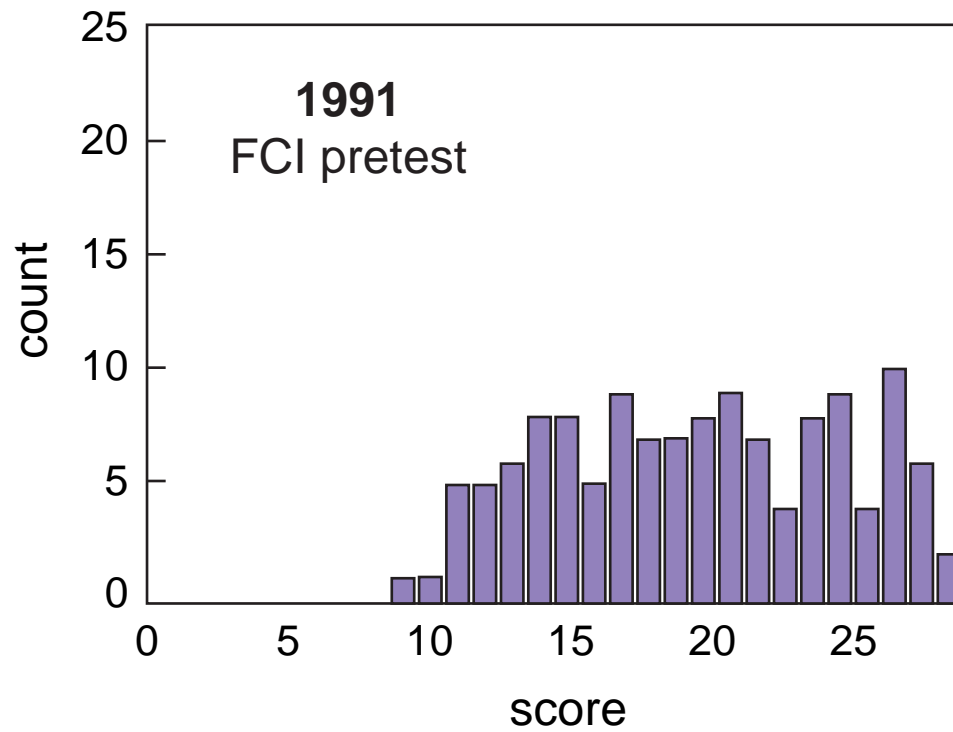
▶ **Results**



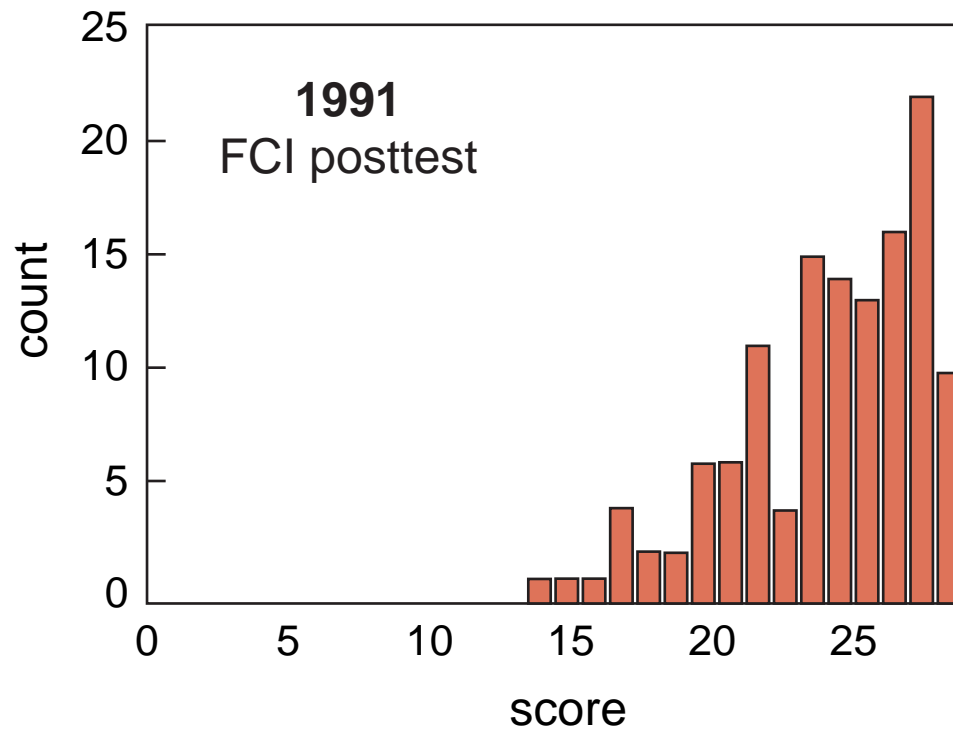
# *Is it any good?*

- ▶ **Results**
- ▶ **Student Reactions**

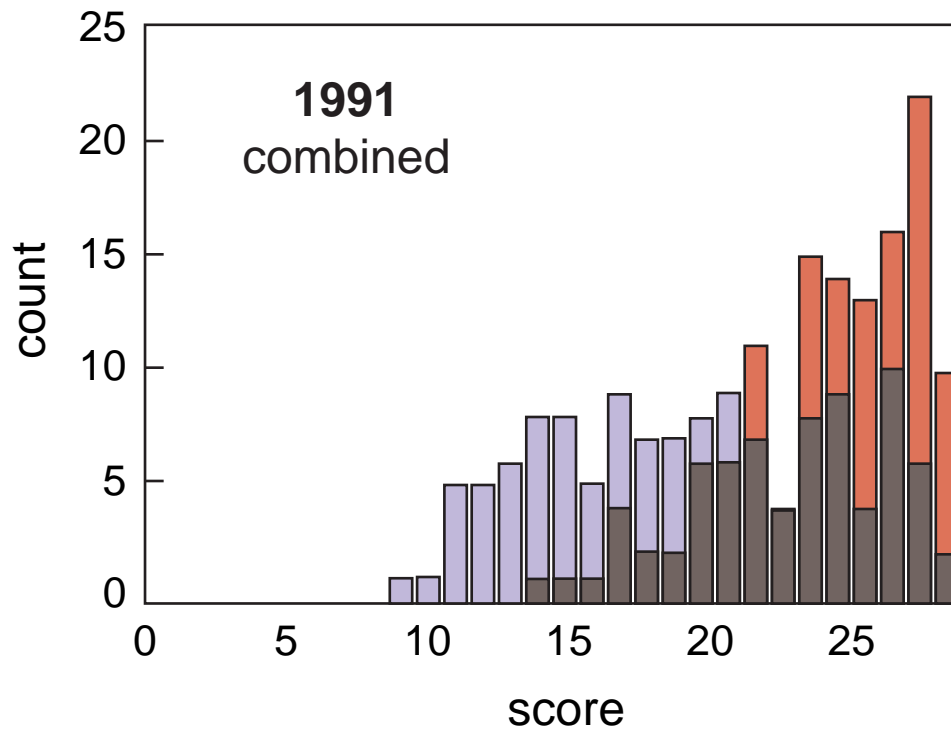
# Results



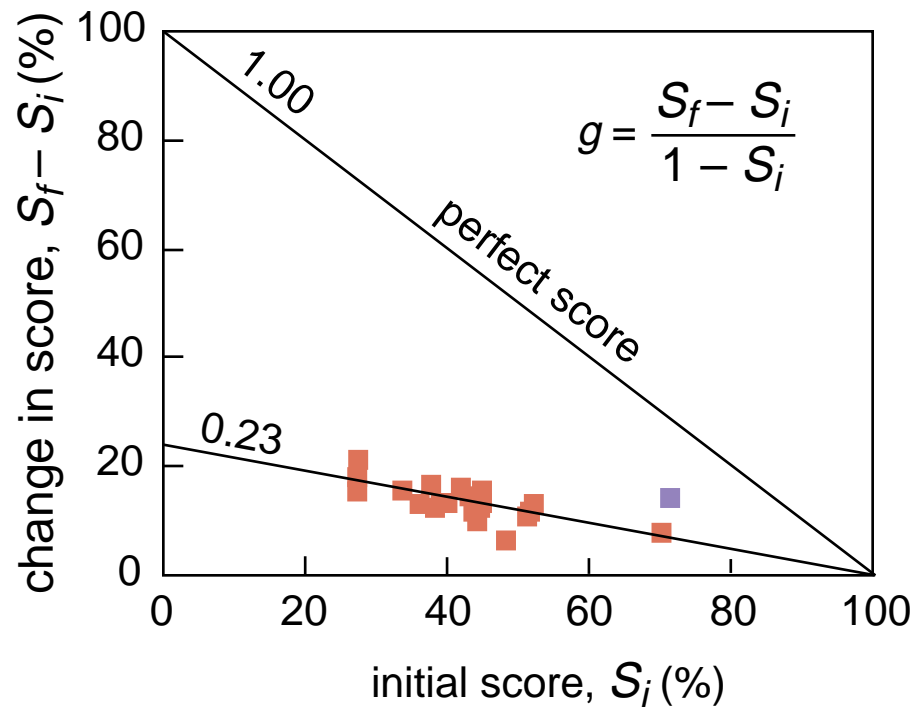
# Results



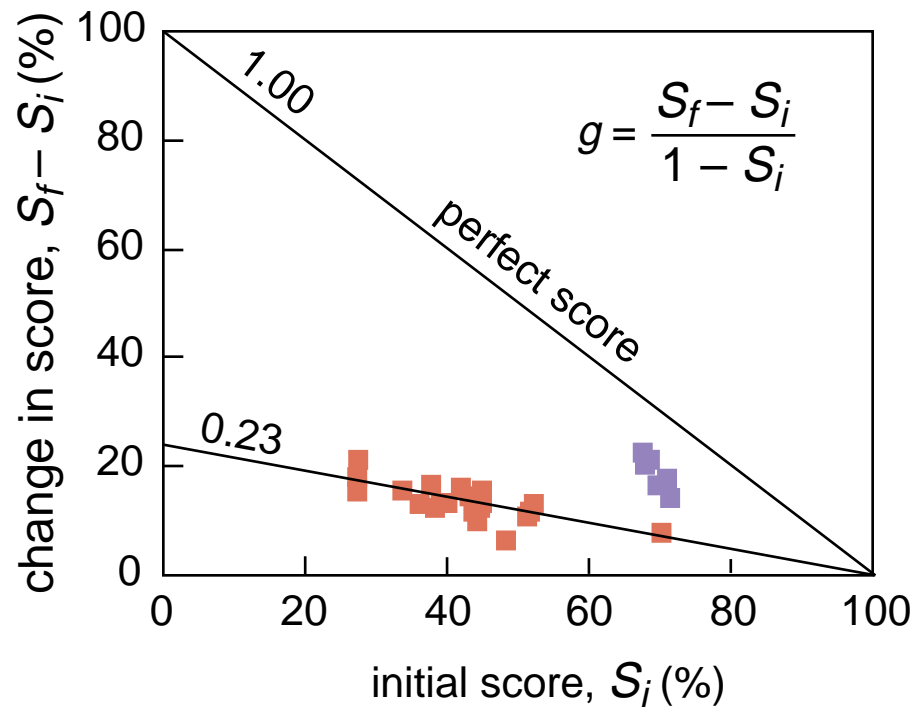
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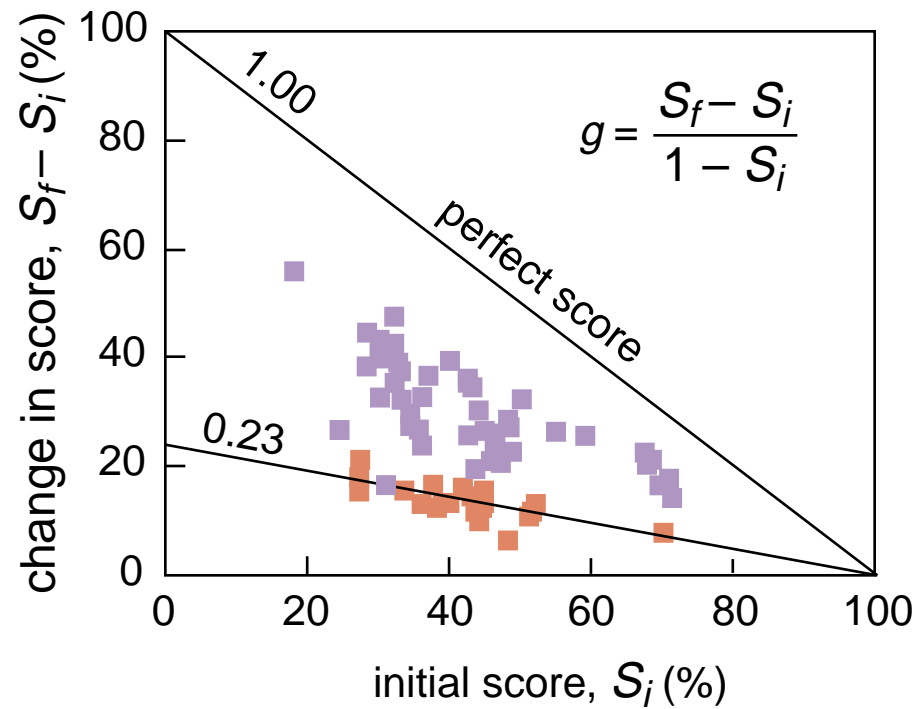
# Results



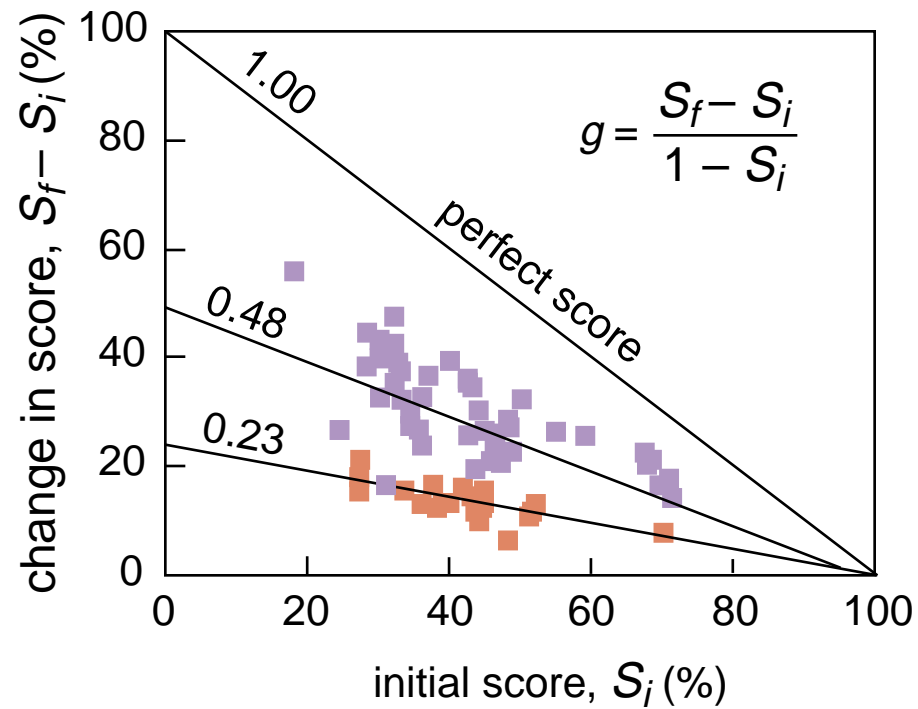
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# Results



# Results

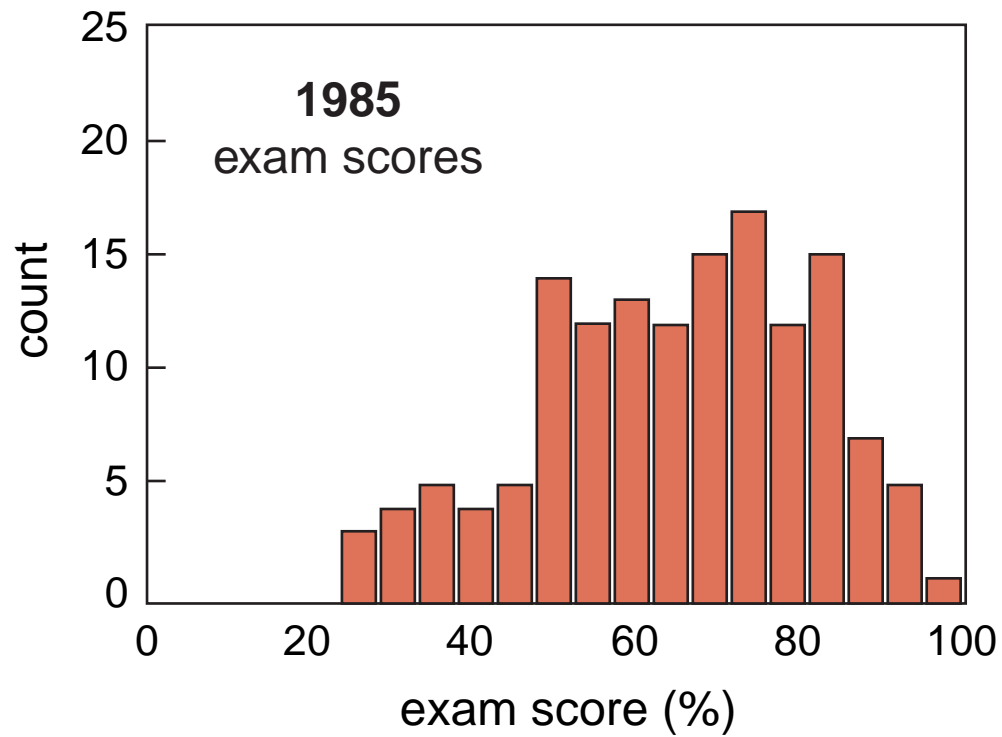




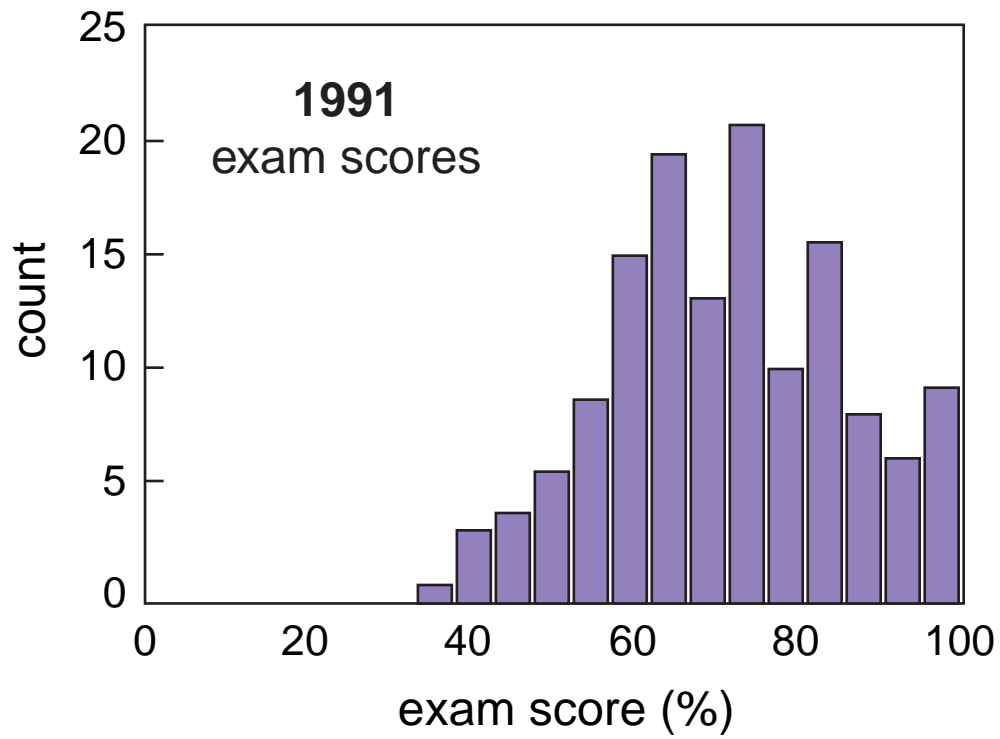
# *Results*

**What about problem solving...?**

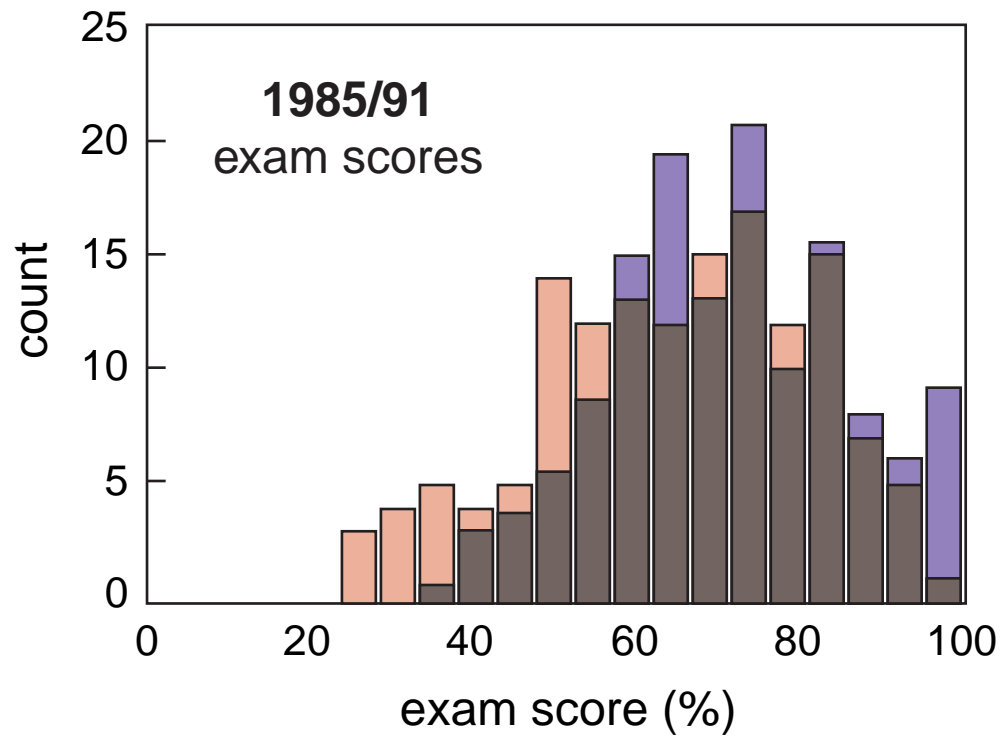
# Results



# Results



# Results



# *Results*

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

# *Results*

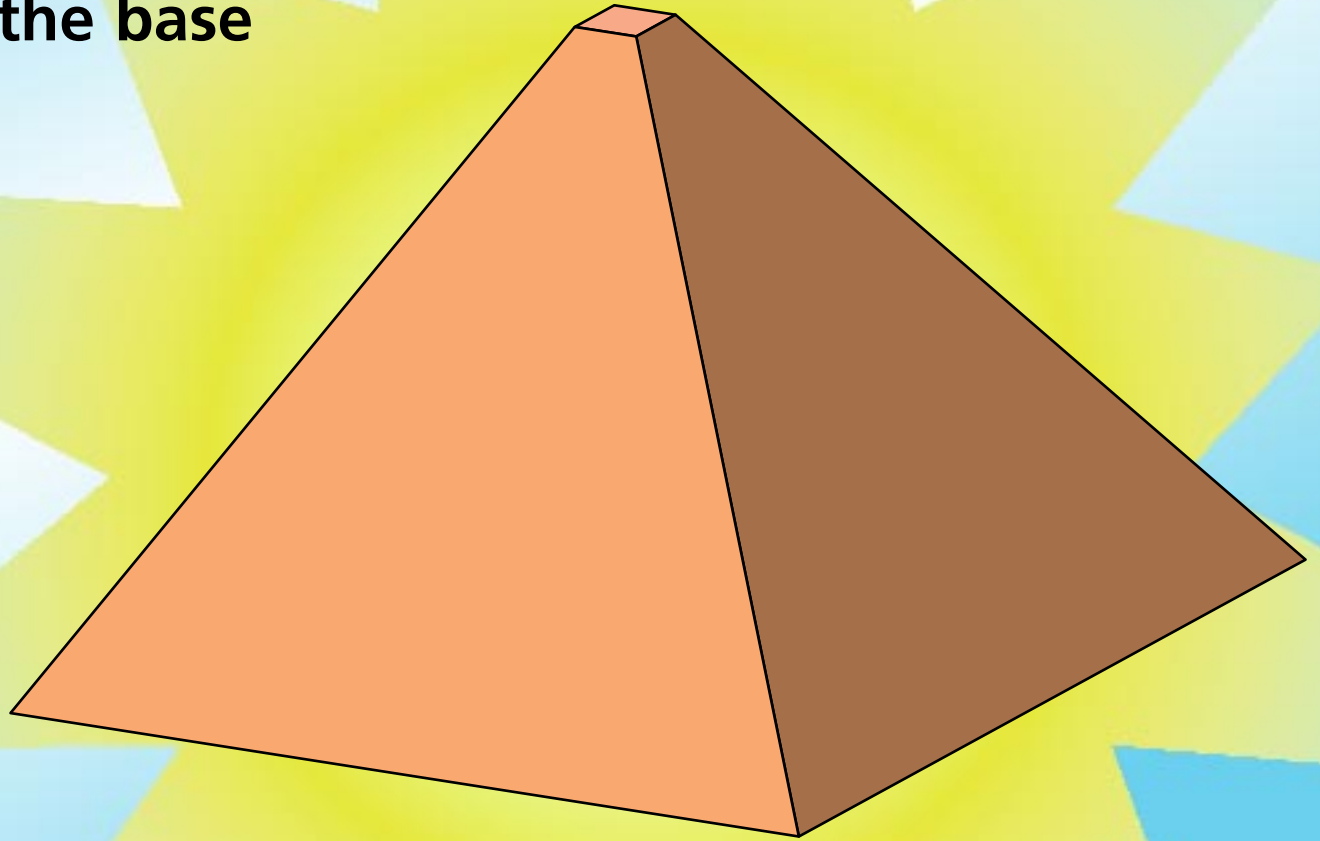
**So better understanding leads to better problem solving!**

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



# *Conclusion*

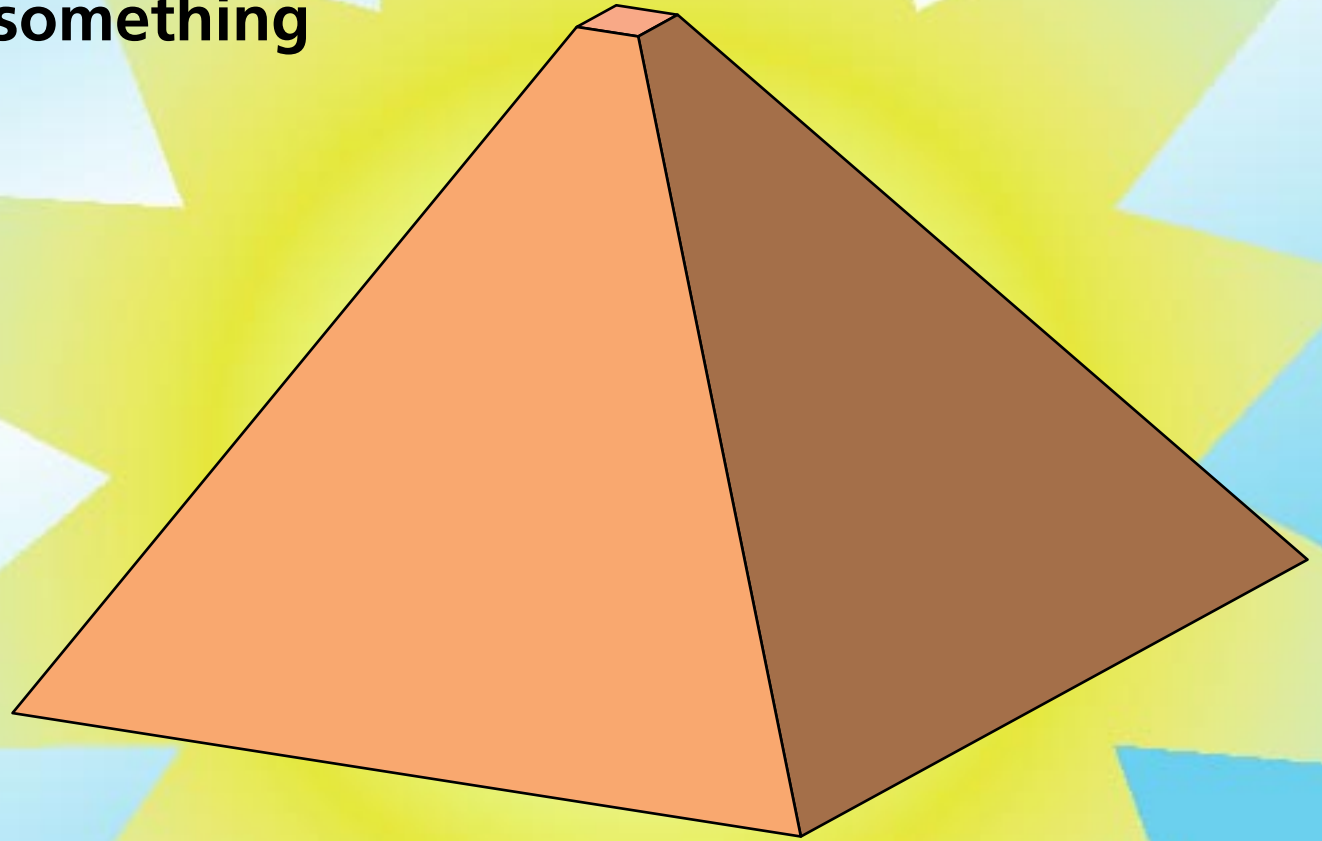
**Let's not forget the base  
of the pyramid!**





# *Conclusion*

**Let's give them something  
of value!**



# *Conclusion*

## Challenges:

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

# *Conclusion*

## Rewards:

- ▶ engagement
- ▶ improved understanding
- ▶ class is fun!

## **Funding**

**National Science Foundation**

**For a copy of this talk and  
additional information:**

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