

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

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**University of Puerto Rico, Rio Piedras  
28 February 2001**



# *Outline*

## ▶ **Problem**

# *Outline*

▶ **Problem**

▶ **Cause**

# *Outline*

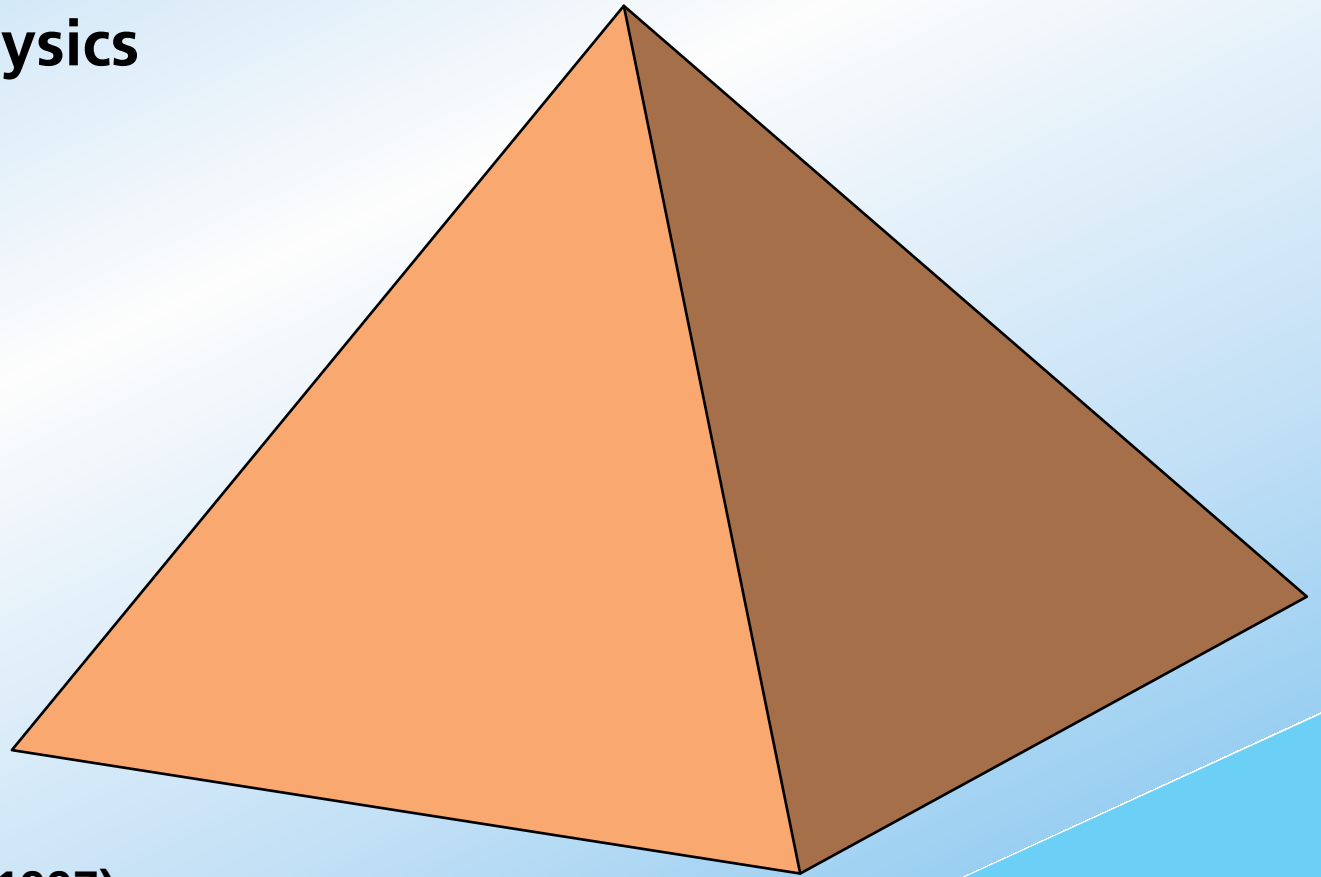
▶ **Problem**

▶ **Cause**

▶ **Remedy**

# ***We have a problem***

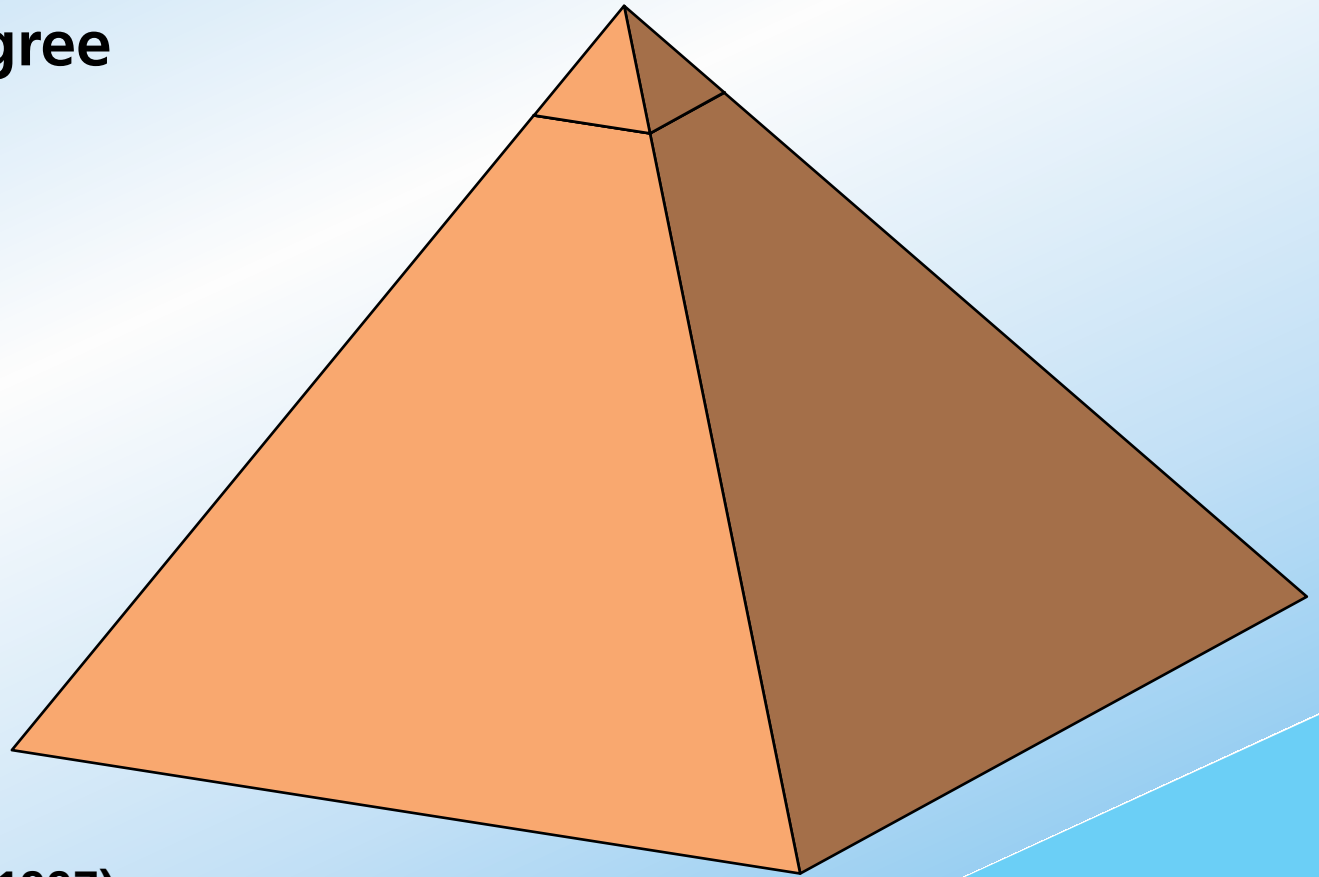
**380,000 students take  
introductory physics  
each year...**



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

# ***We have a problem***

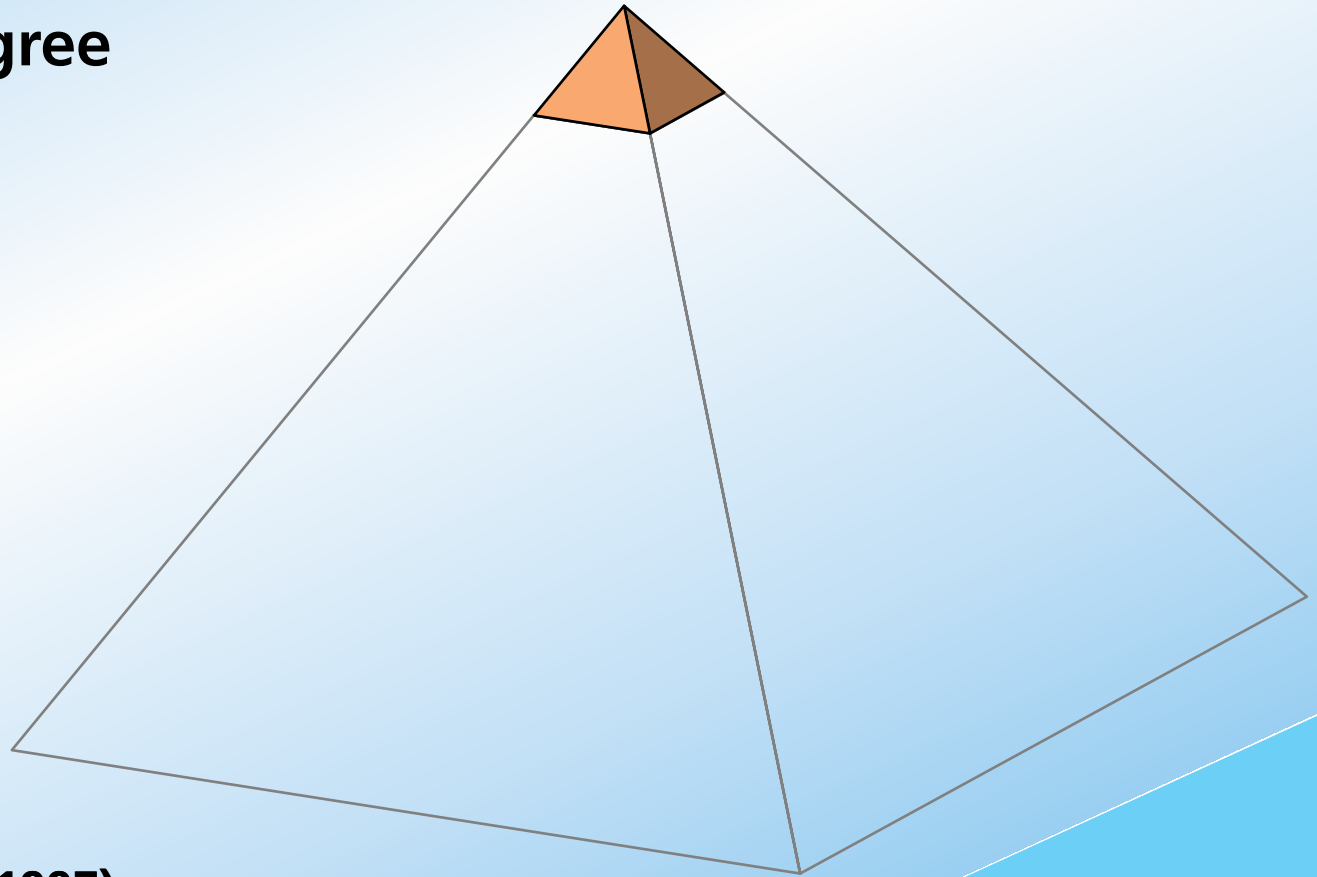
**about 1% of these get  
a bachelor's degree  
in physics**



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

# ***We have a problem***

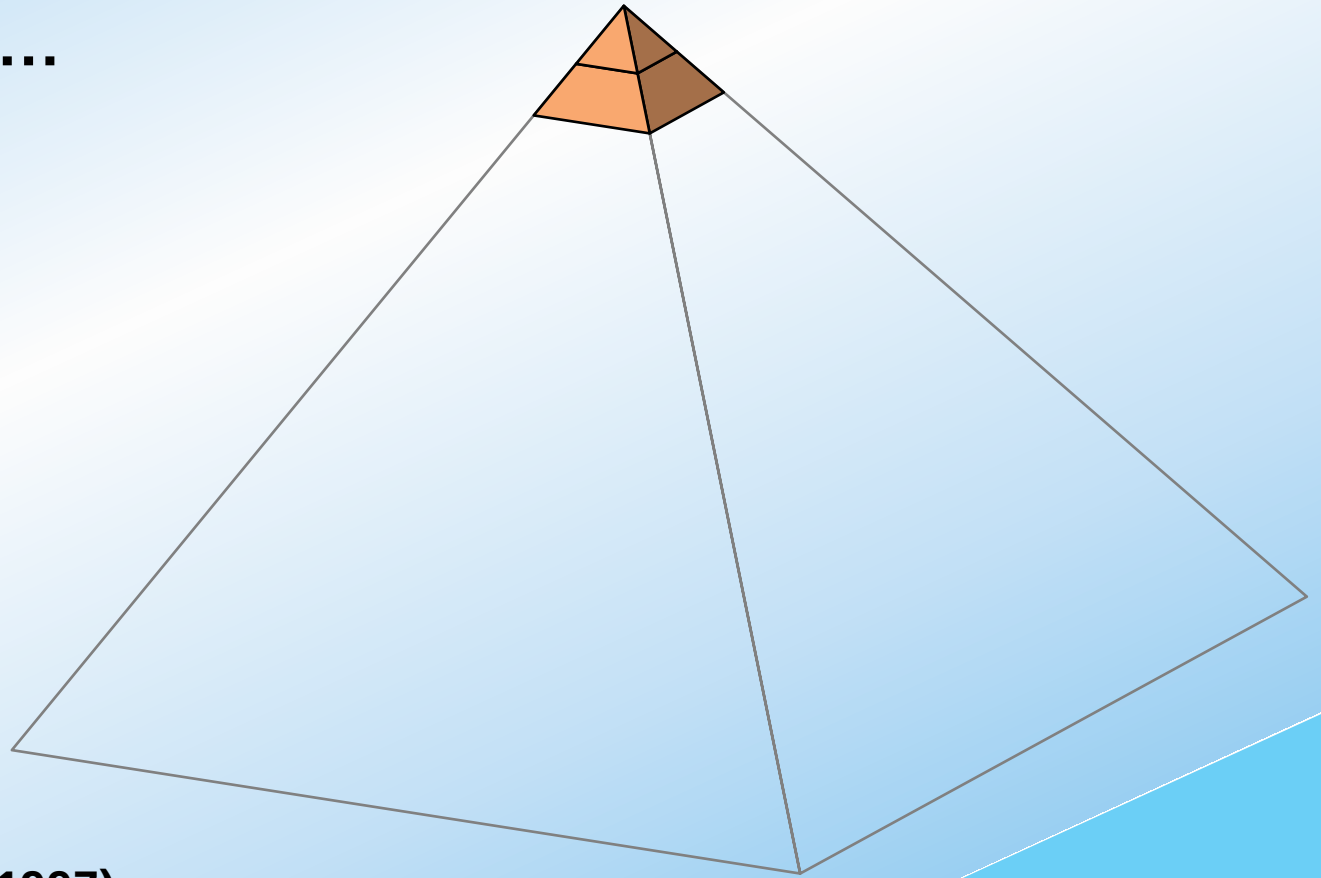
**Of the 4,300 students with  
a bachelor's degree  
in physics...**



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

# ***We have a problem***

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

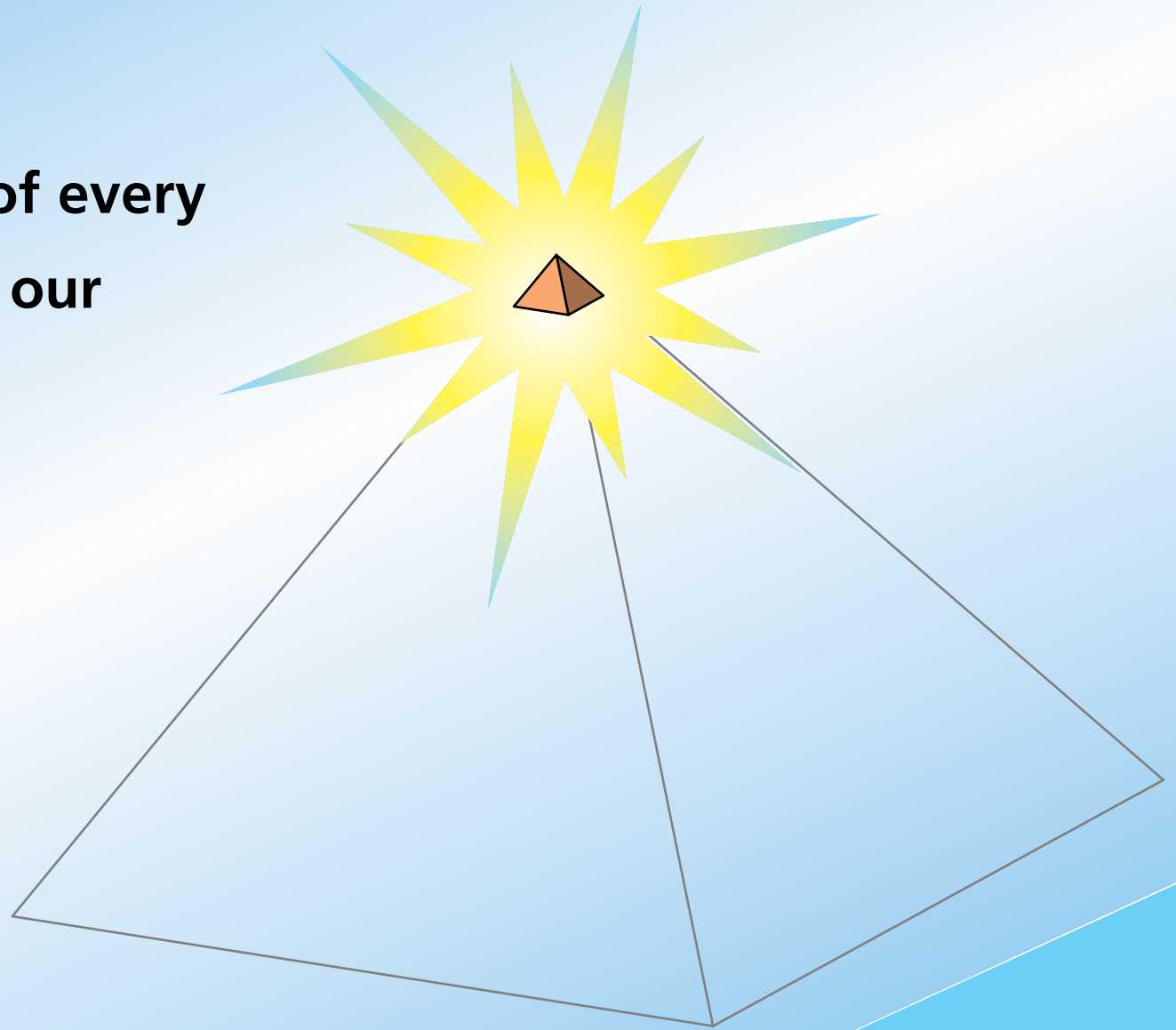


***AIP Report R-151.33 (1997)***



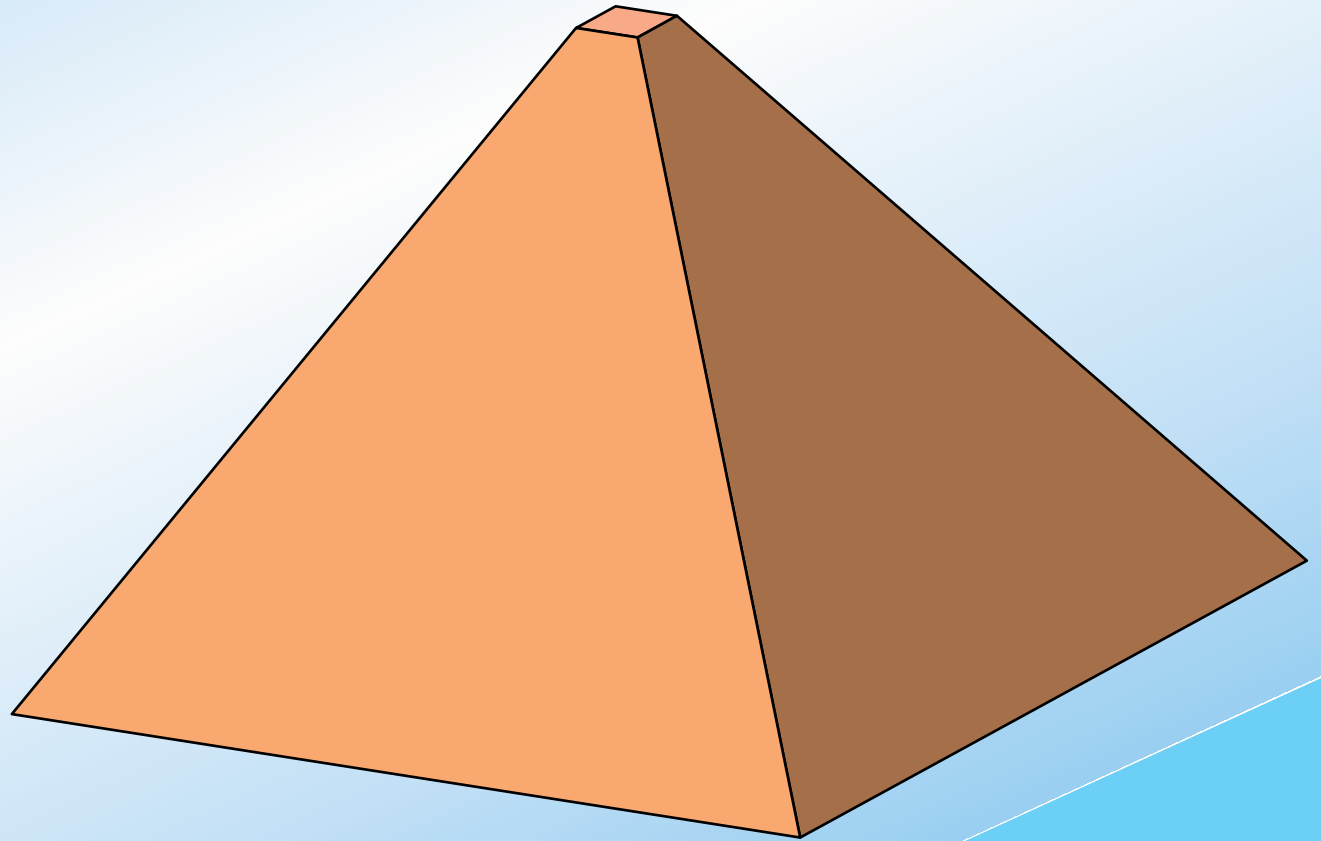
# ***We have a problem***

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



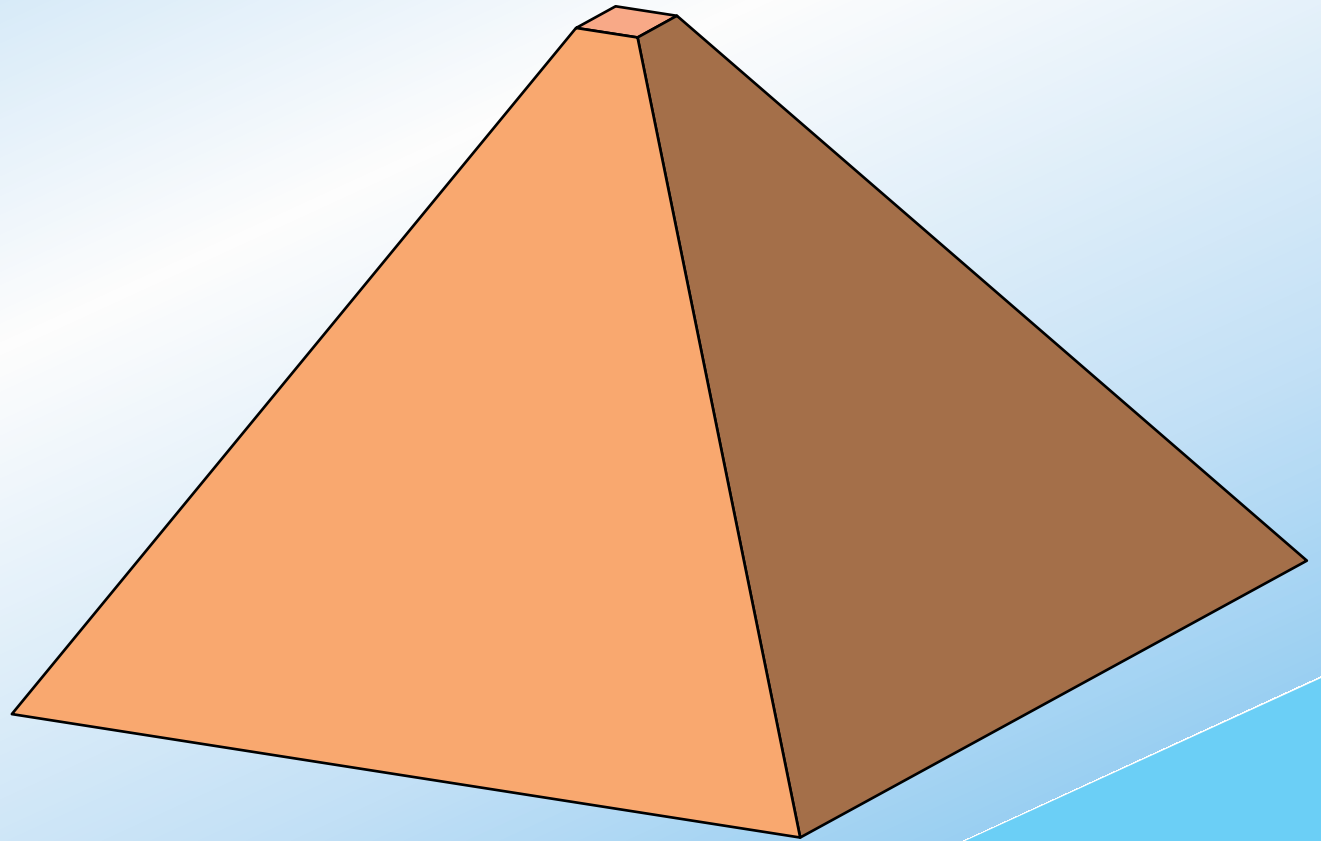
*We have a problem*

**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 transperence 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, slightly blurred photograph of a diverse group of young people, likely students, smiling and looking towards the left side of the frame. The image has a warm, slightly desaturated color palette. The text "Why do we have this problem?" is overlaid in the lower center of the image.

**Why do we have this problem?**

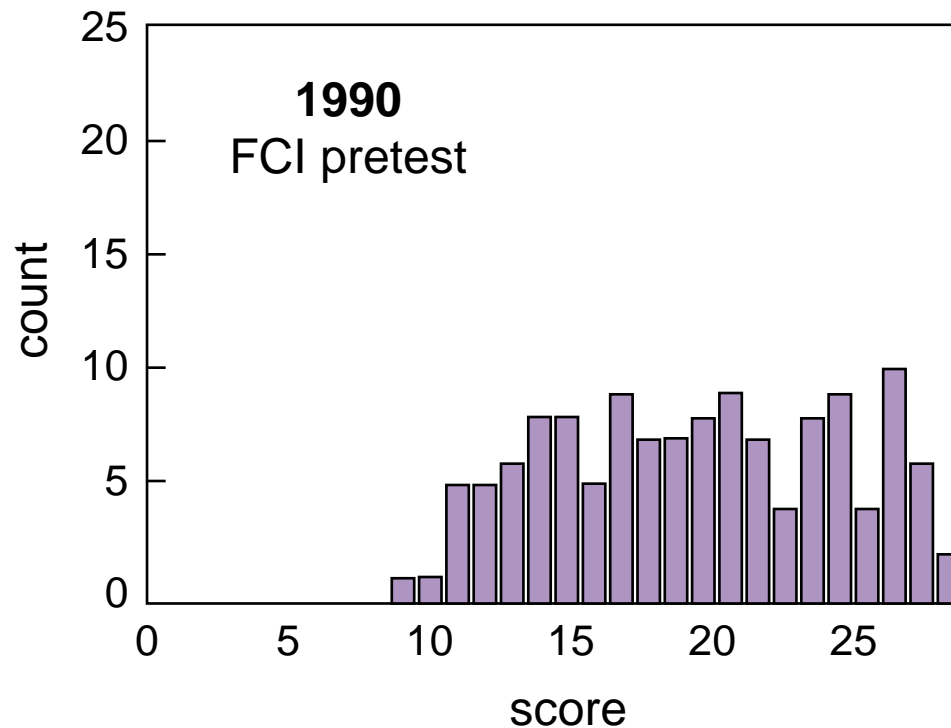


## *Why do we have this problem?*

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

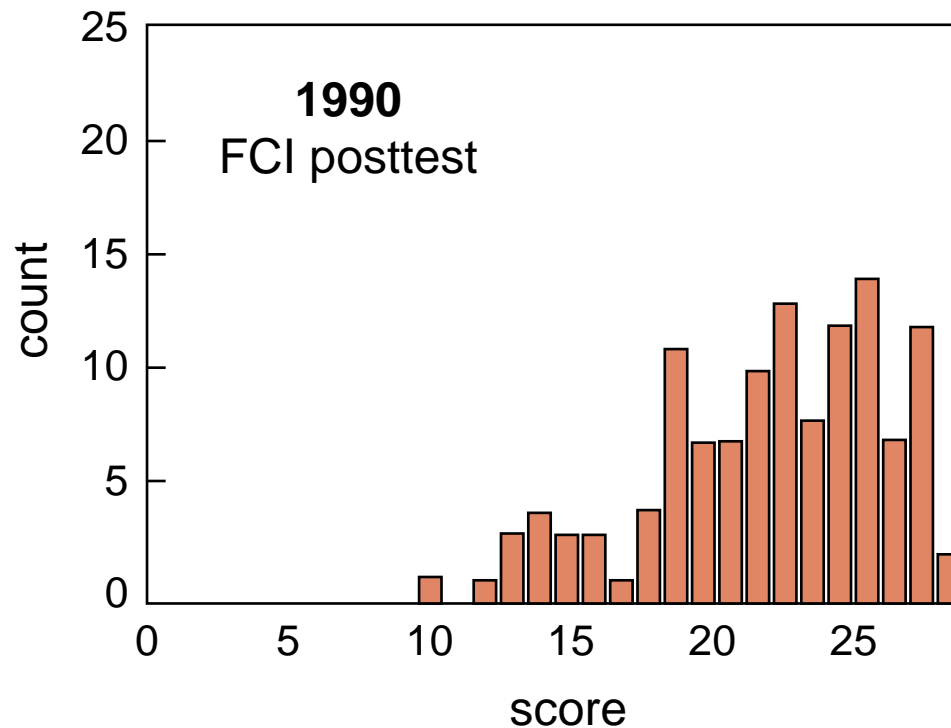
# *Why do we have this problem?*

...but physics is not just information!



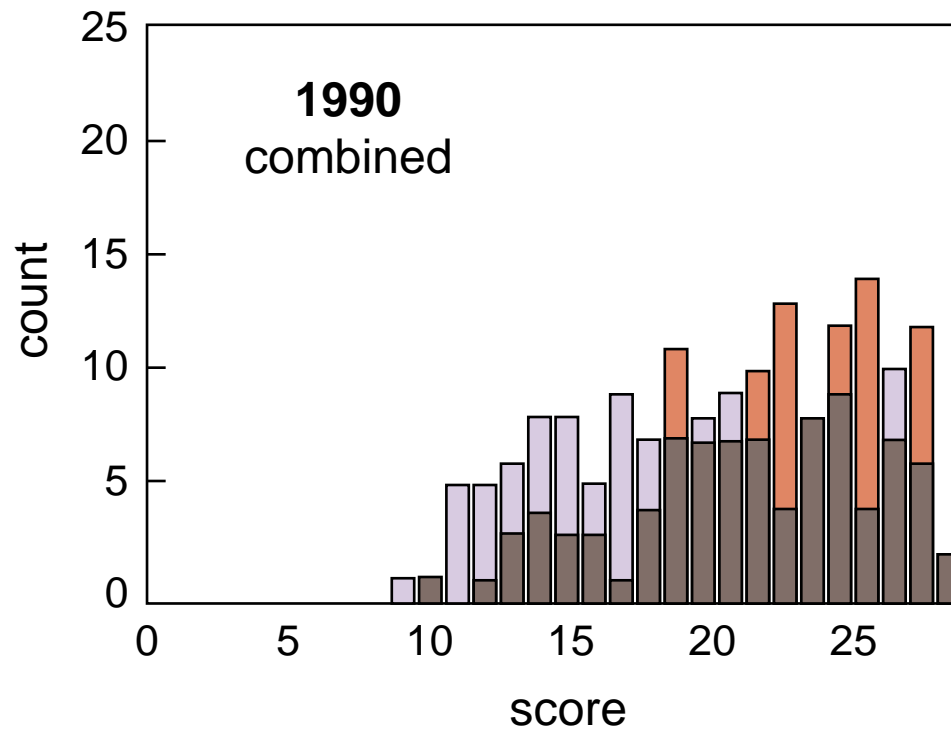
# *Why do we have this problem?*

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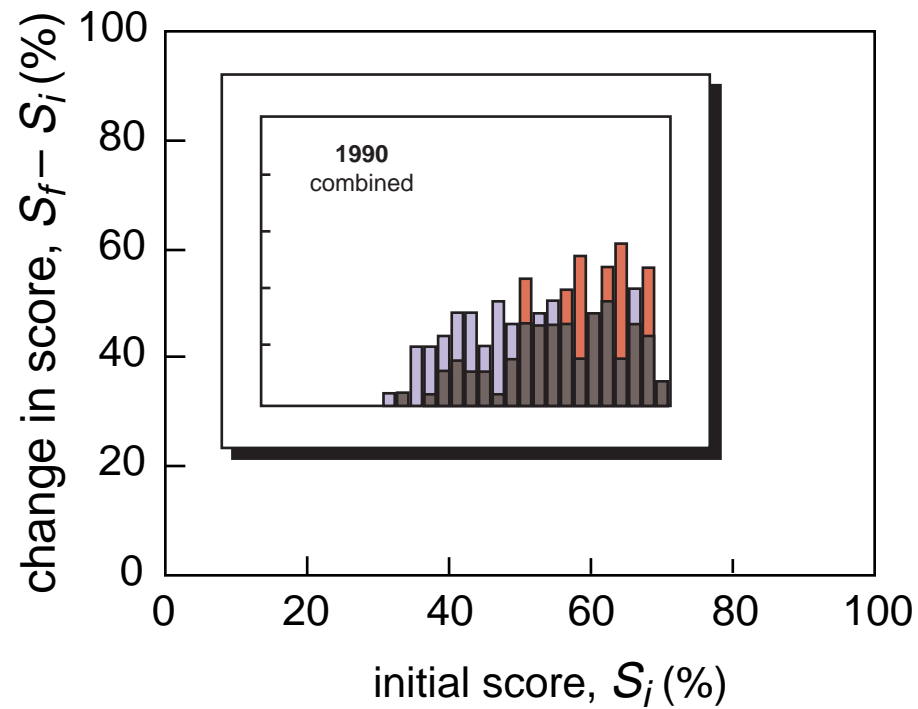


# *Why do we have this problem?*

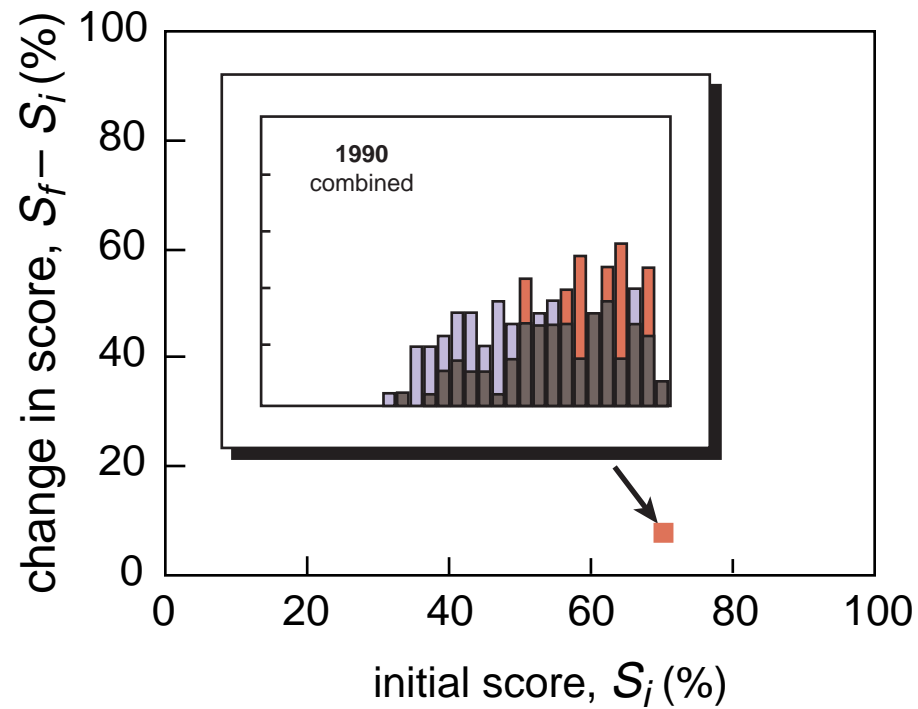
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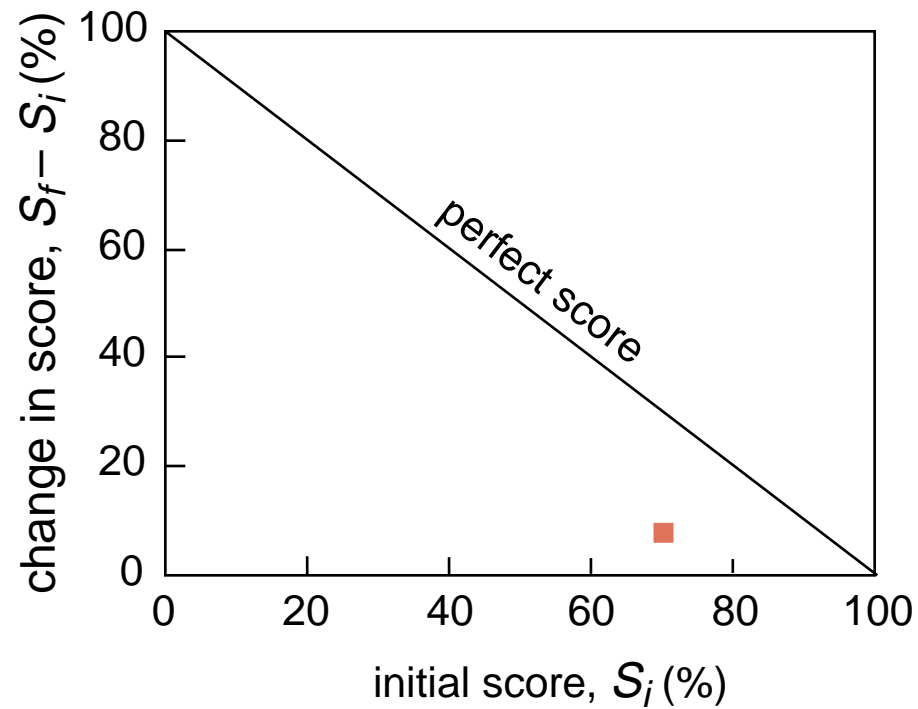
# *Why do we have this problem?*



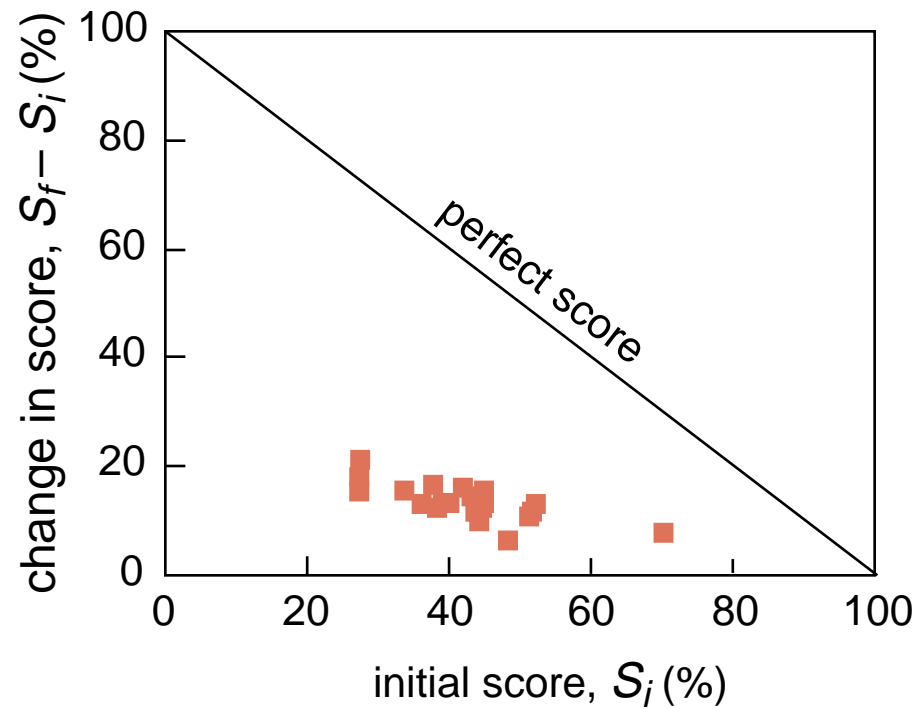
# *Why do we have this problem?*



## *Why do we have this problem?*

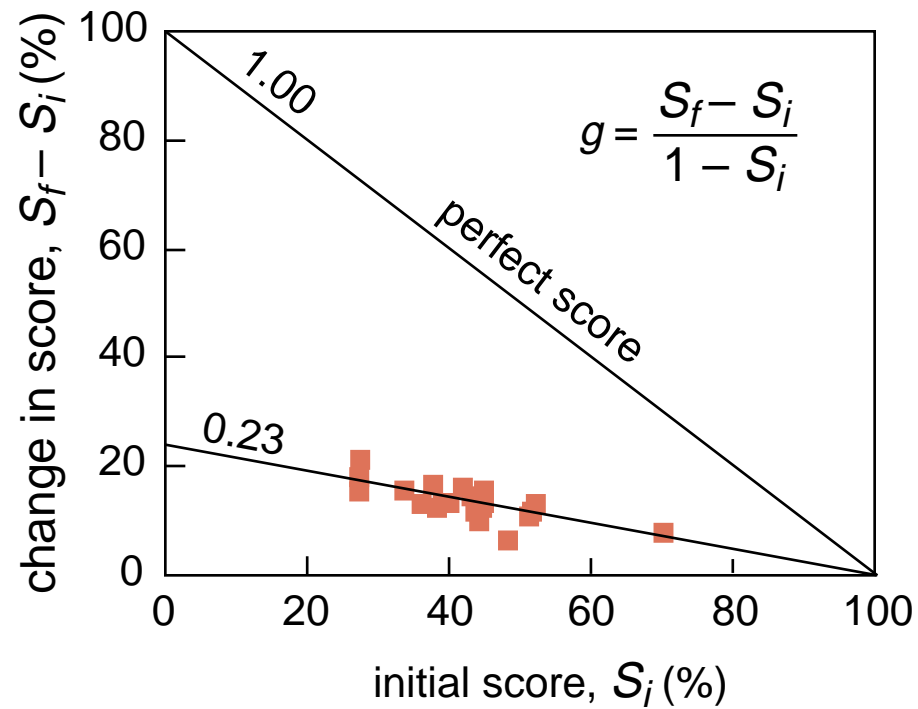


## *Why do we have this problem?*





# Why do we have this problem?

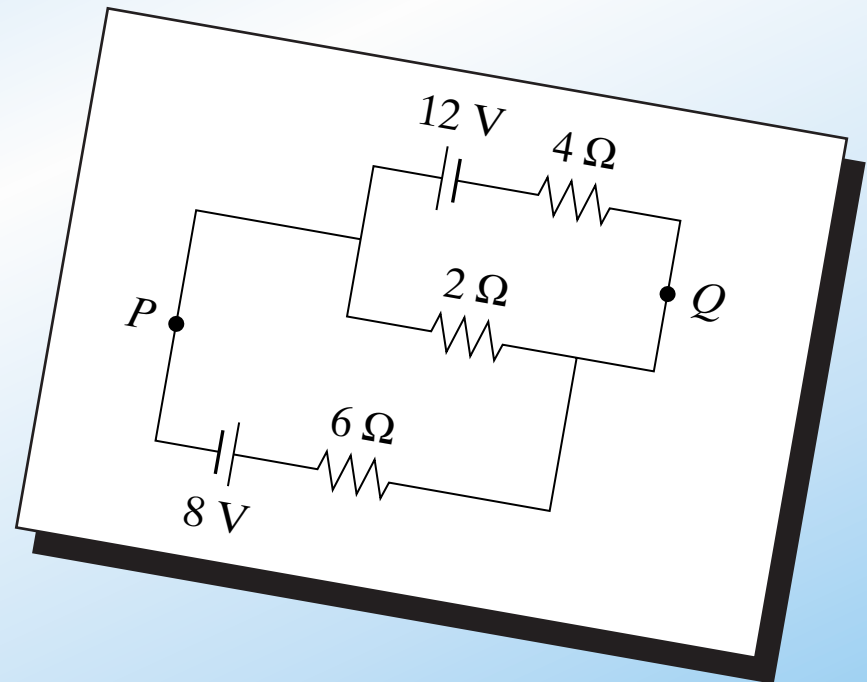


## *Why do we have this problem?*

**Conventional problems reinforce bad study habits**

## *Why do we have this problem?*

**Conventional problems reinforce bad study habits**

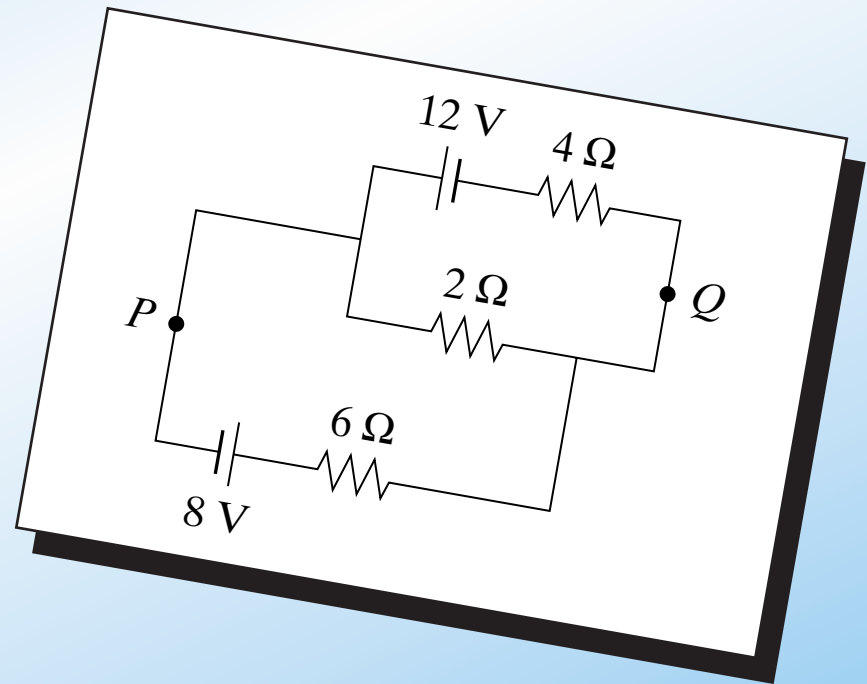


## *Why do we have this problem?*

### Conventional problems reinforce bad study habits

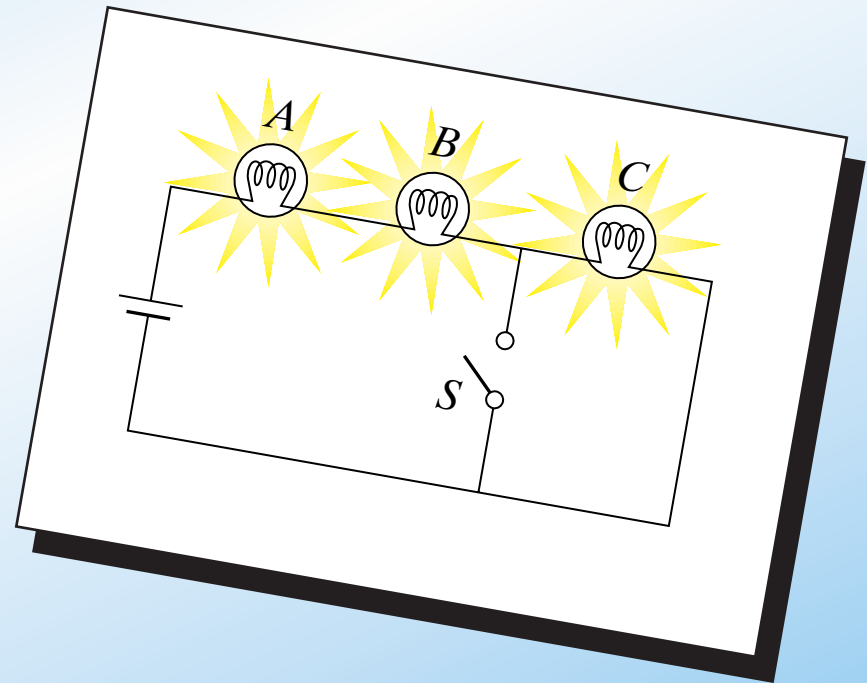
Calculate:

- (a) 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?**

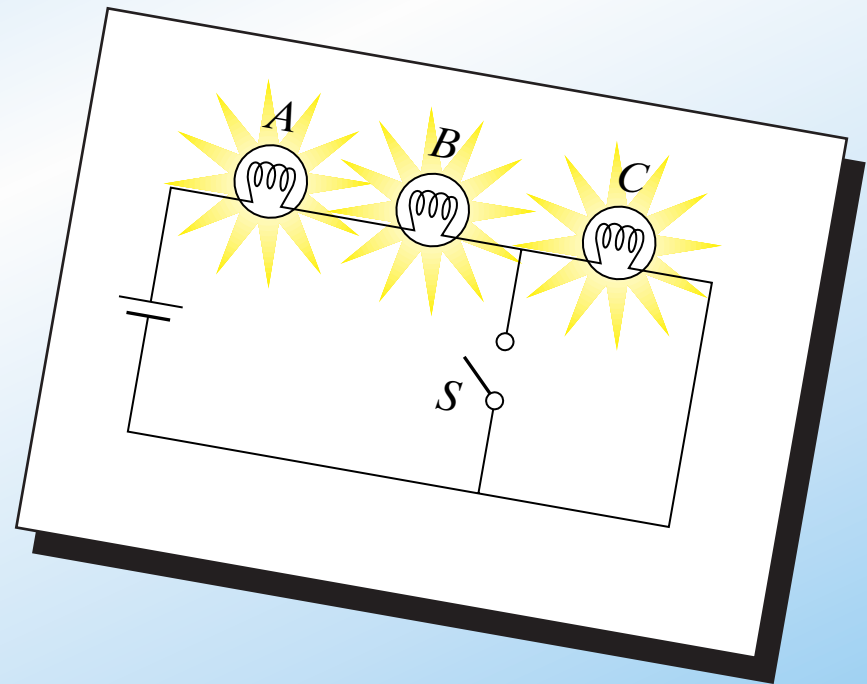


# *Why do we have this problem?*

## Are basic principles understood?

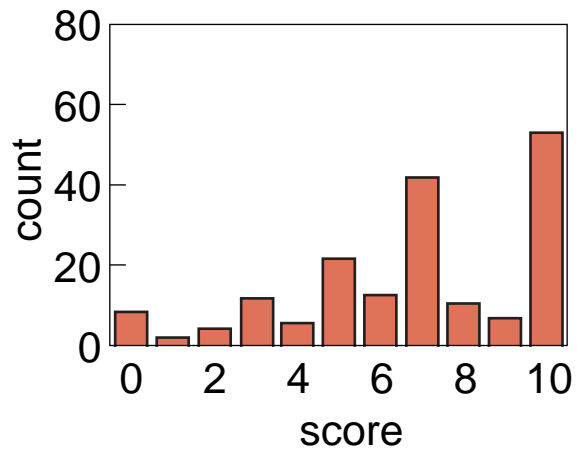
When  $S$  is closed, what happens to the:

- (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?

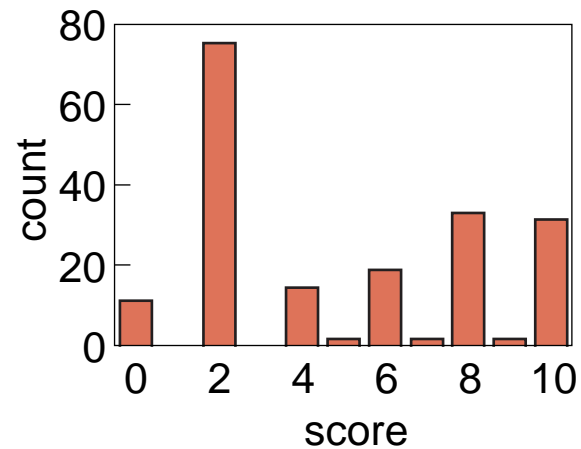


# *Why do we have this problem?*

**conventional**

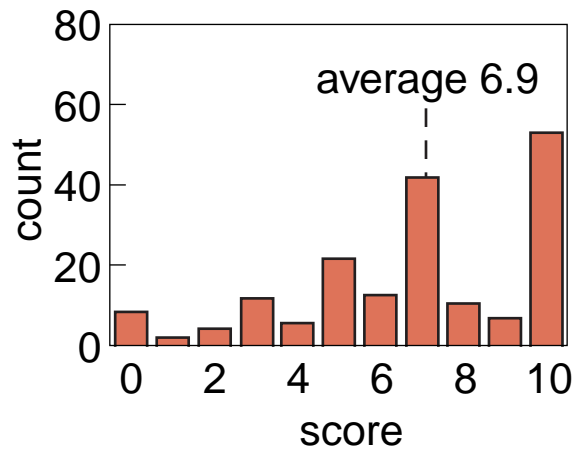


**conceptual**

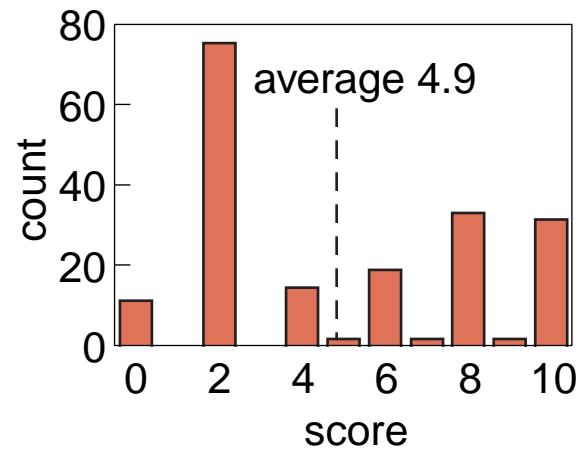


# *Why do we have this problem?*

**conventional**

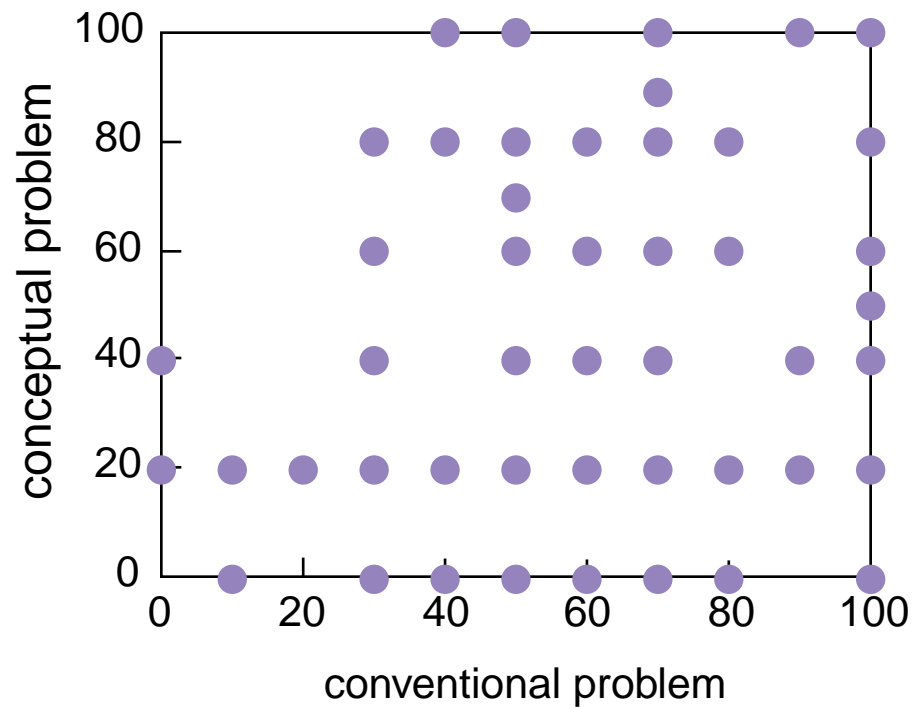


**conceptual**

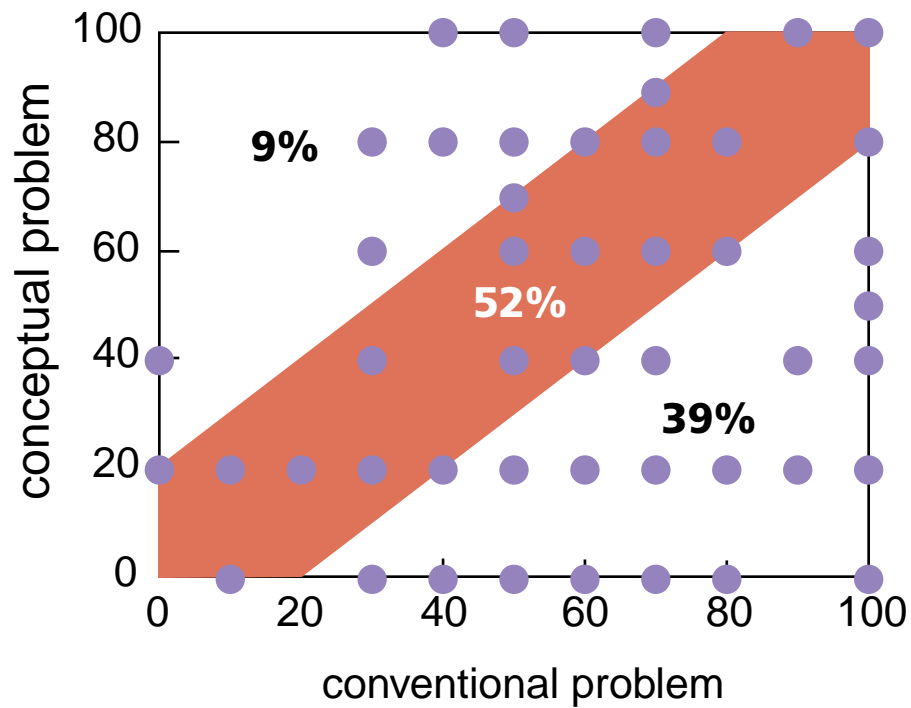




# *Why do we have this problem?*



# *Why do we have this problem?*



So what should we do?



# *Peer Instruction*

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

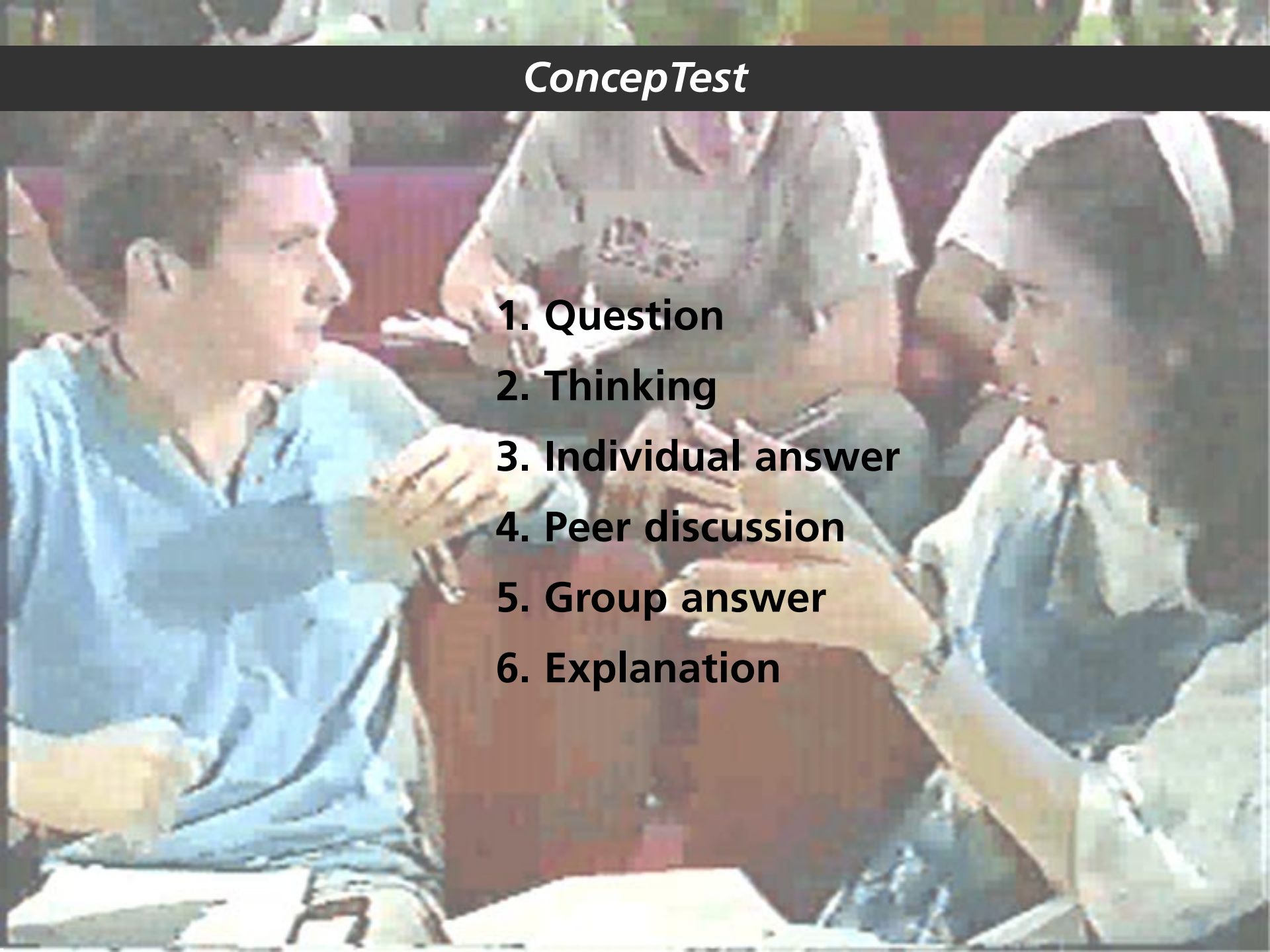
# *Peer Instruction*

## **Main features:**

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



# *ConcepTest*

- 
- A photograph of three students in a classroom. On the left, a male student in a blue shirt is looking towards the center. In the middle, a female student in a grey shirt is looking down at a book or paper. On the right, a female student in a blue shirt is looking towards the center. They appear to be engaged in a discussion or activity.
- 1. Question**
  - 2. Thinking**
  - 3. Individual answer**
  - 4. Peer discussion**
  - 5. Group answer**
  - 6. Explanation**

*Is it any good?*

*Is it any good?*

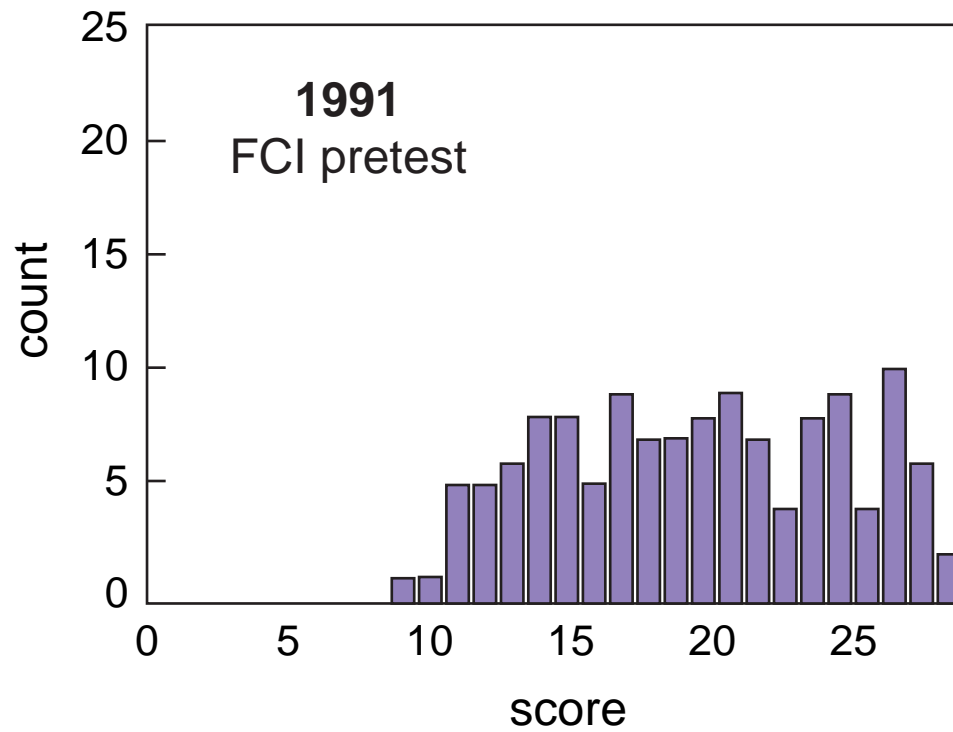
► **Results**



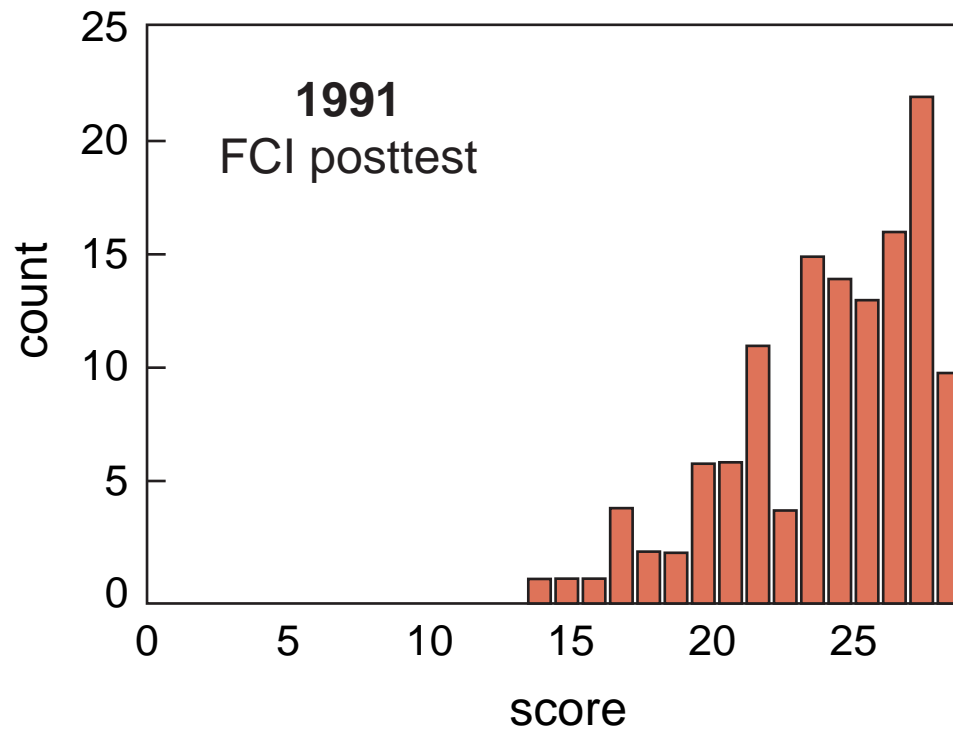
# *Is it any good?*

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

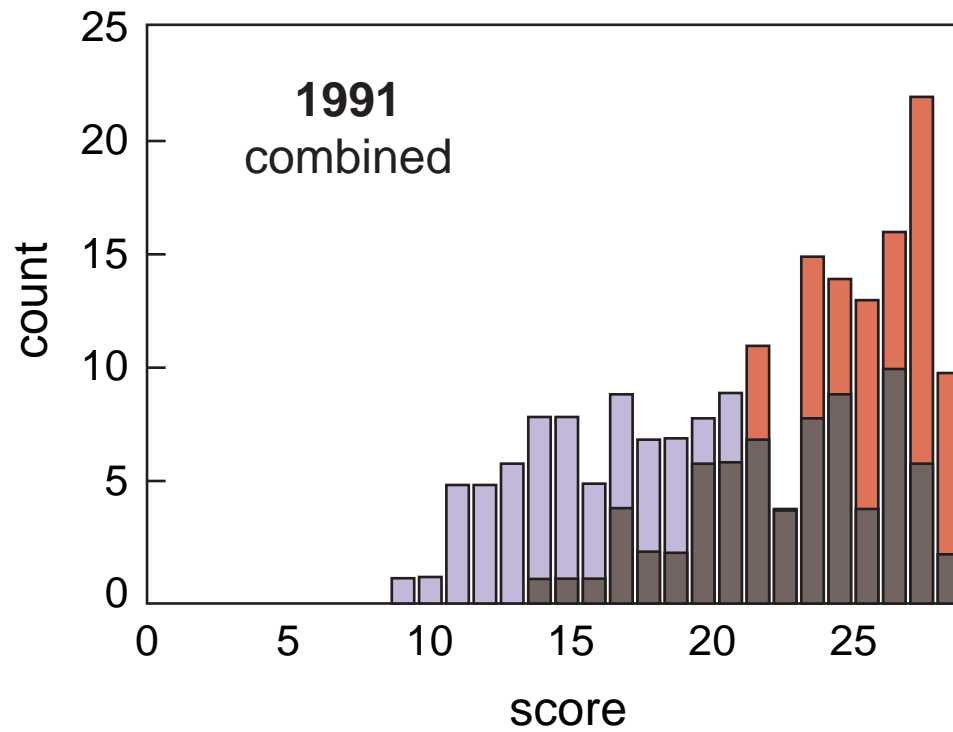
# Results



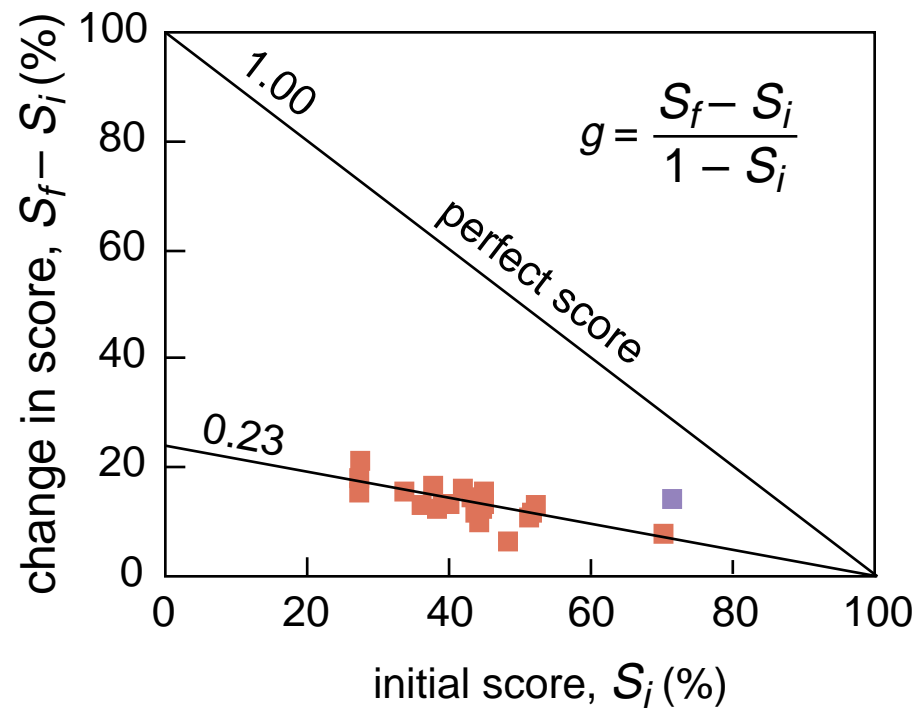
# Results



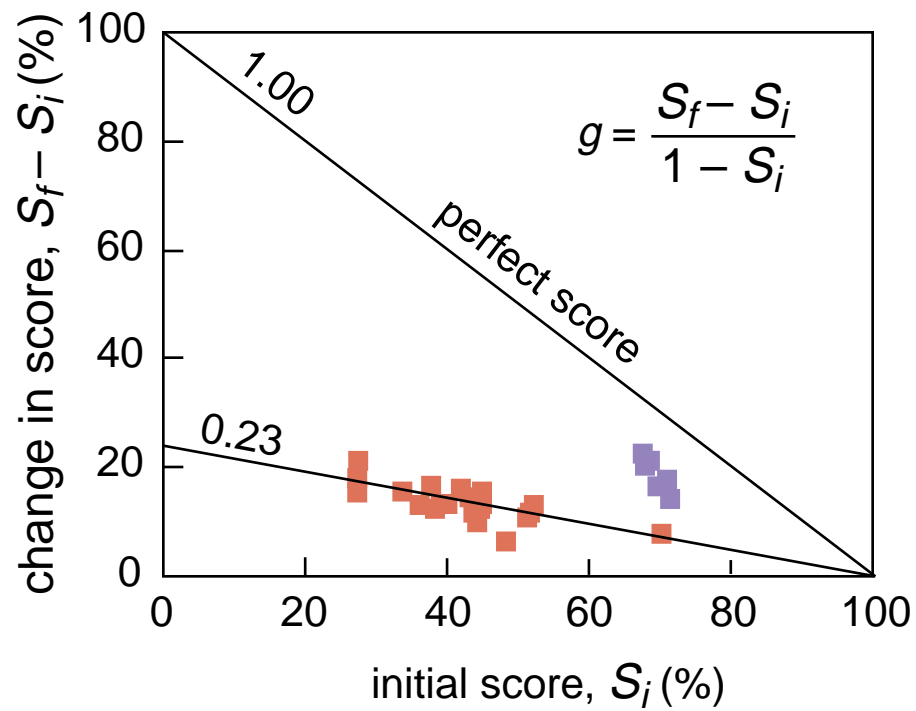
# Results



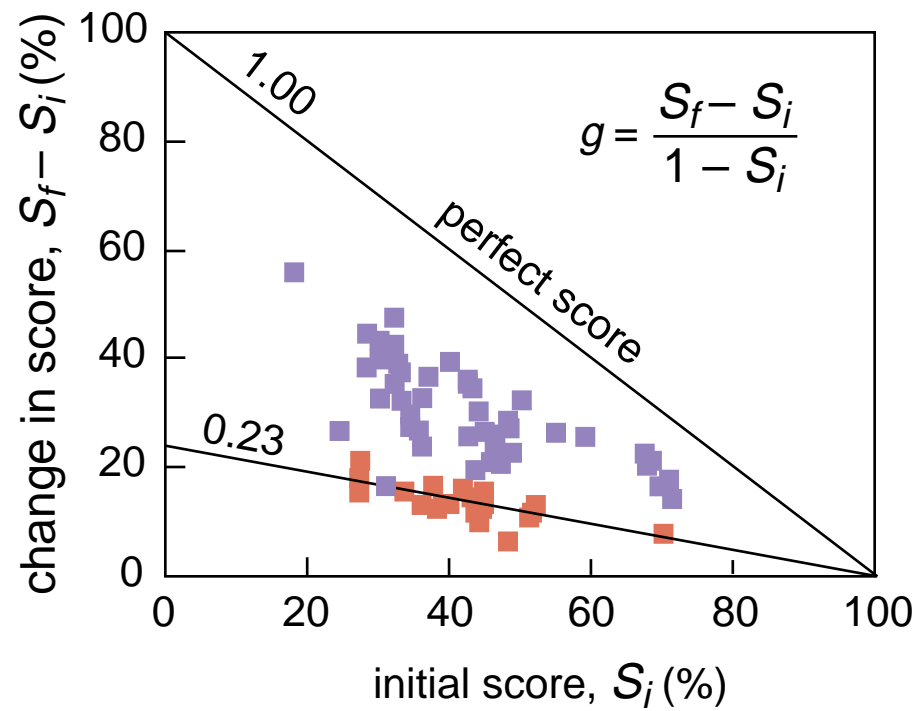
# Results



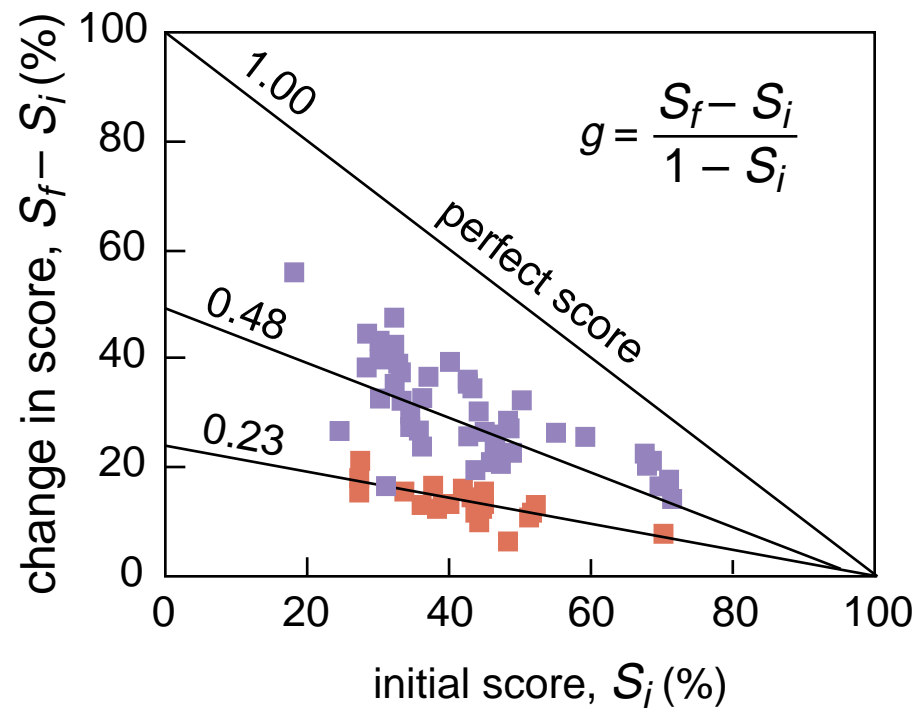
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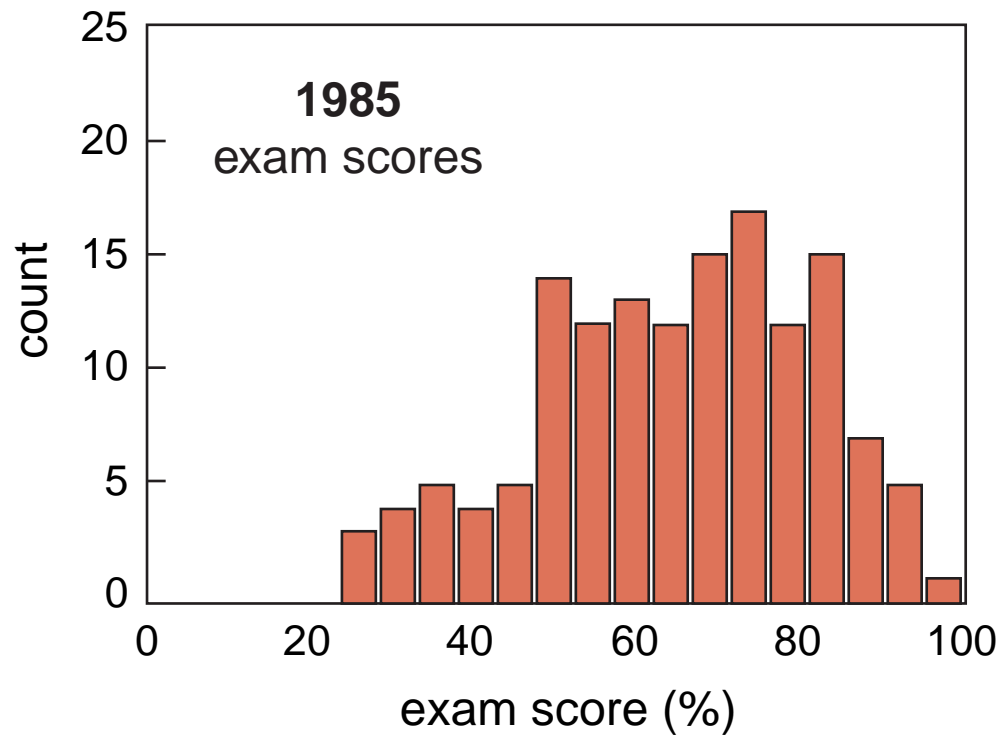




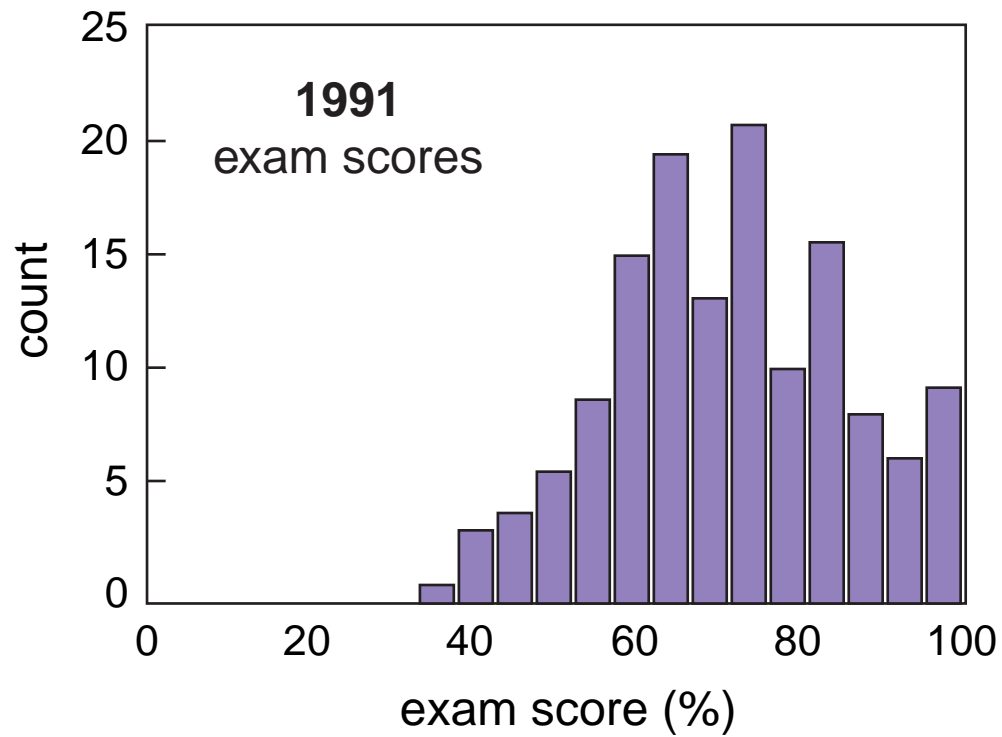
# *Results*

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

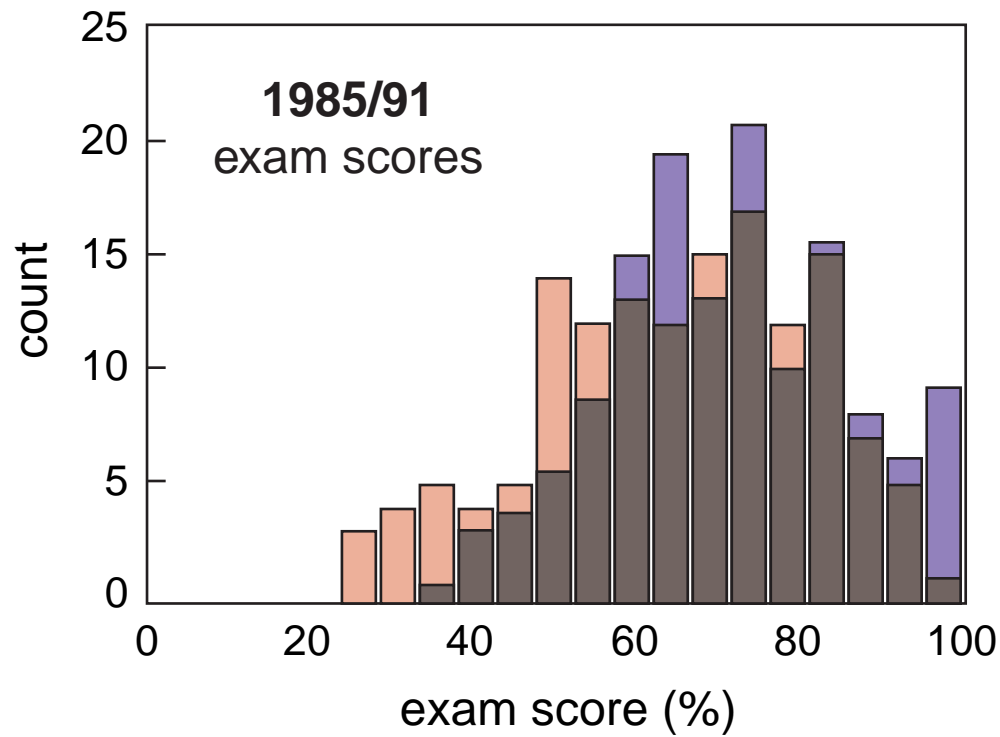
# Results



# Results



# Results



## ***Results***

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

## ***Results***

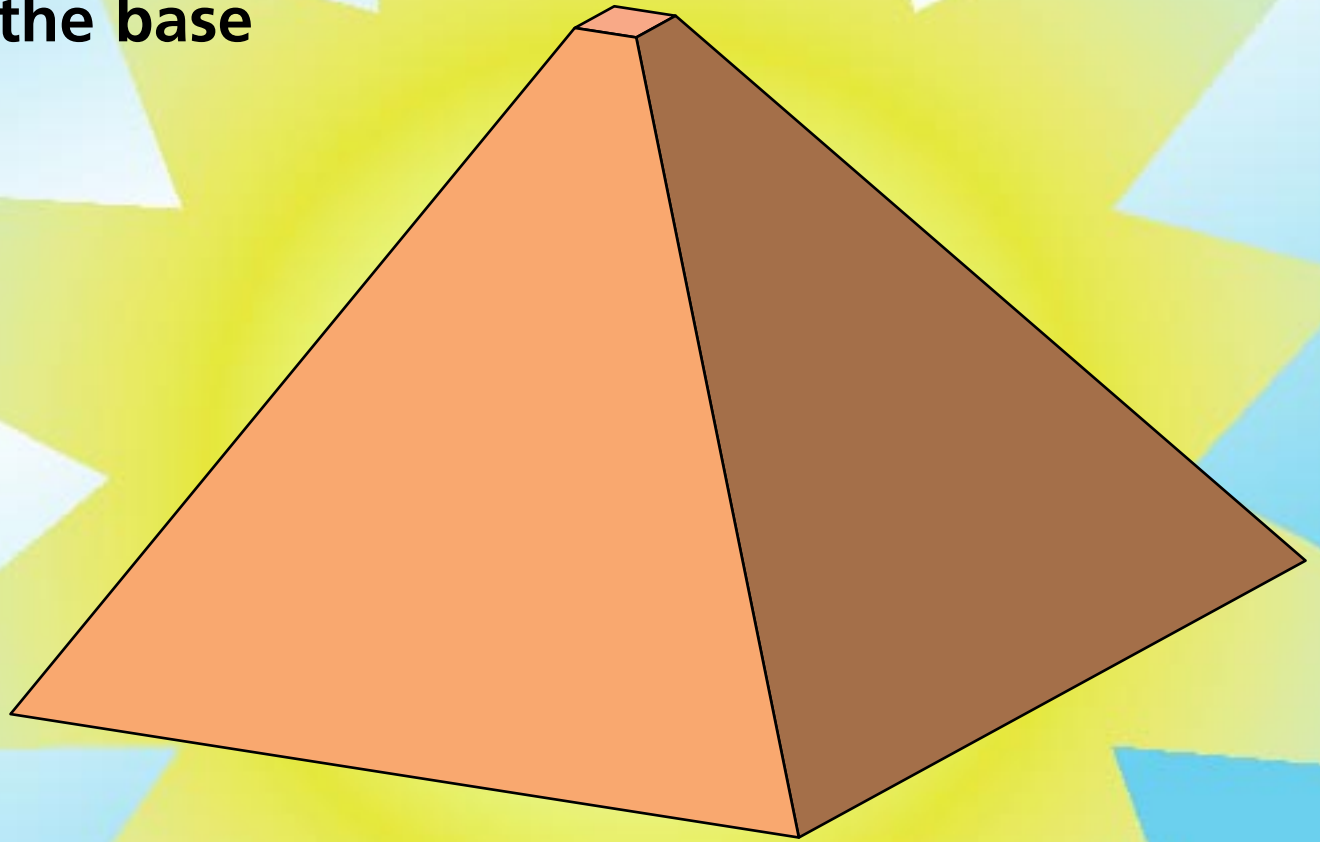
**So better understanding leads to better problem solving!**

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



# *Conclusion*

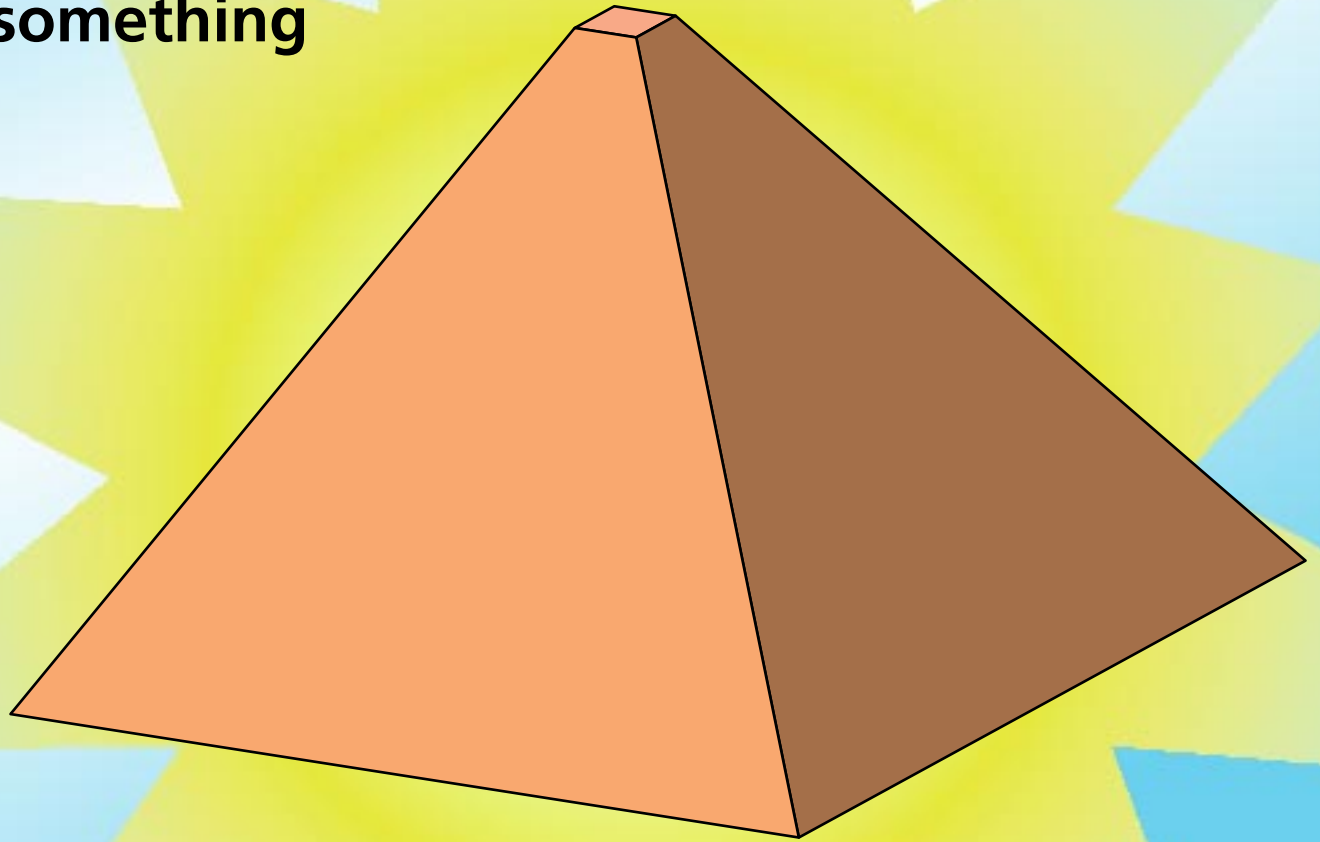
**Let's not forget the base  
of the pyramid!**





# *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>**