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

**Eric Mazur**

**University of Missouri-Rolla**
**12 April 2001**

# *Outline*

- **Problem**

# *Outline*

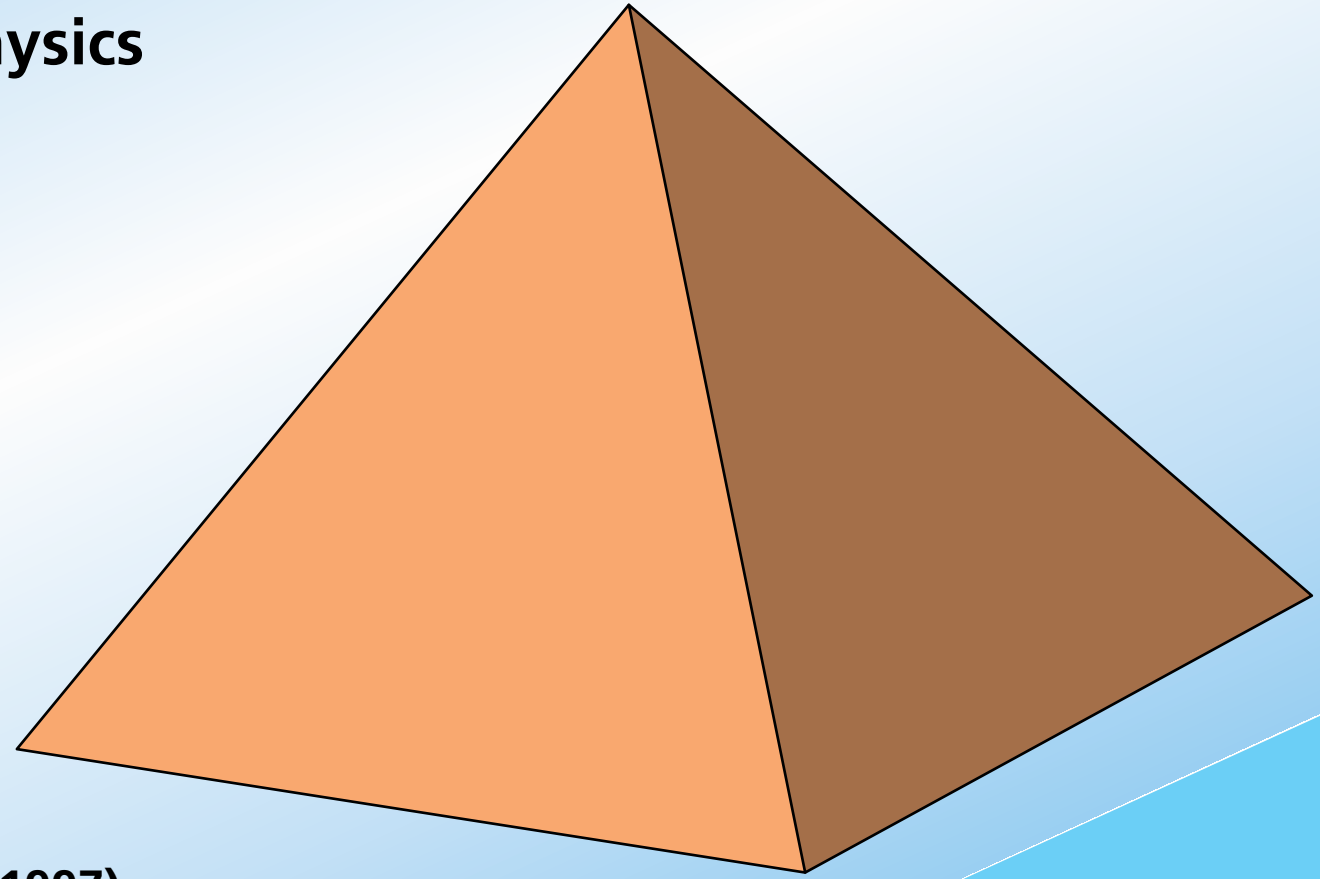
- **Problem**
- **Cause**

# *Outline*

- **Problem**
- **Cause**
- **Remedy**

# *We have a problem*

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



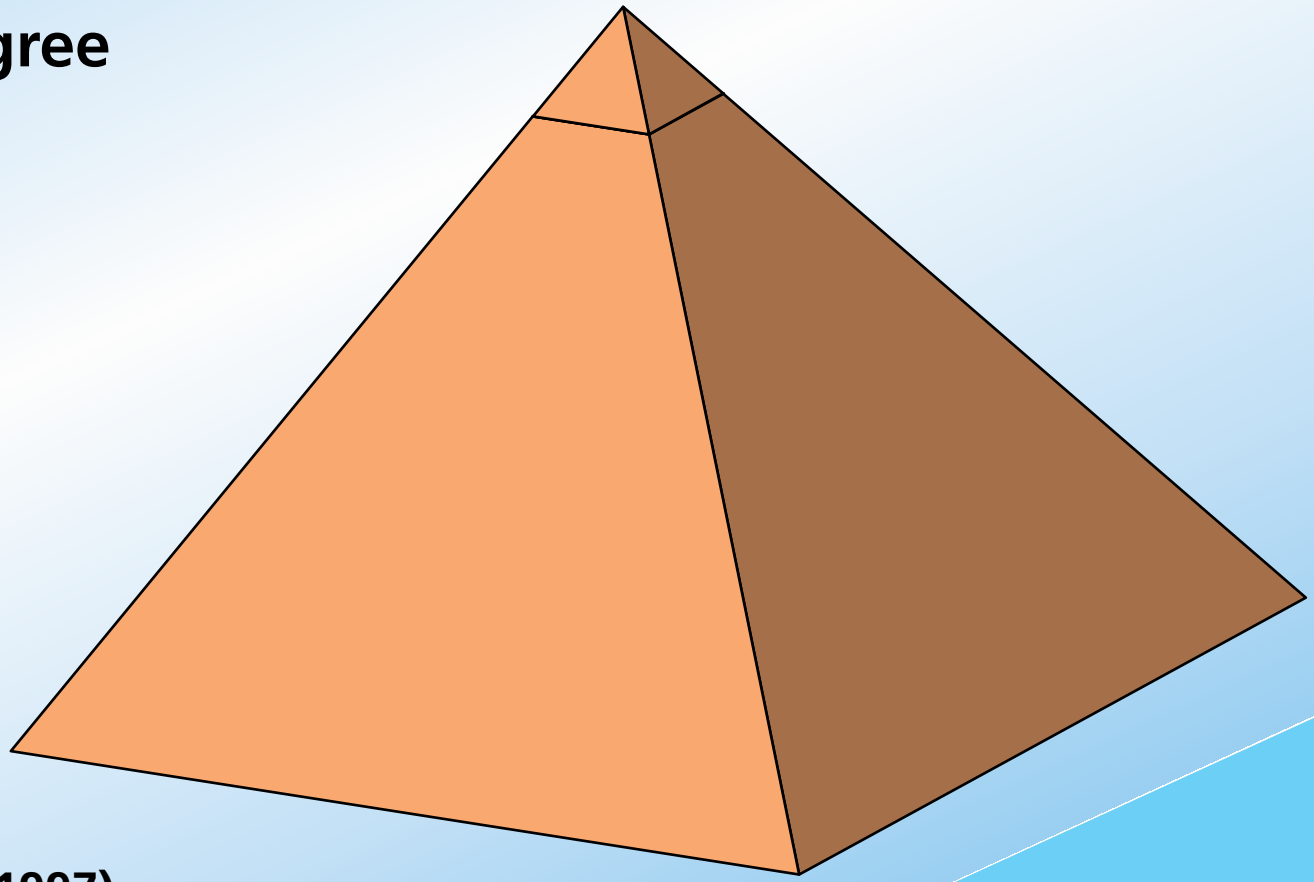
***AIP Report R-151.33*** **(1997)**

# *We have a problem*

**about 1% of these get**

**a bachelor's degree**

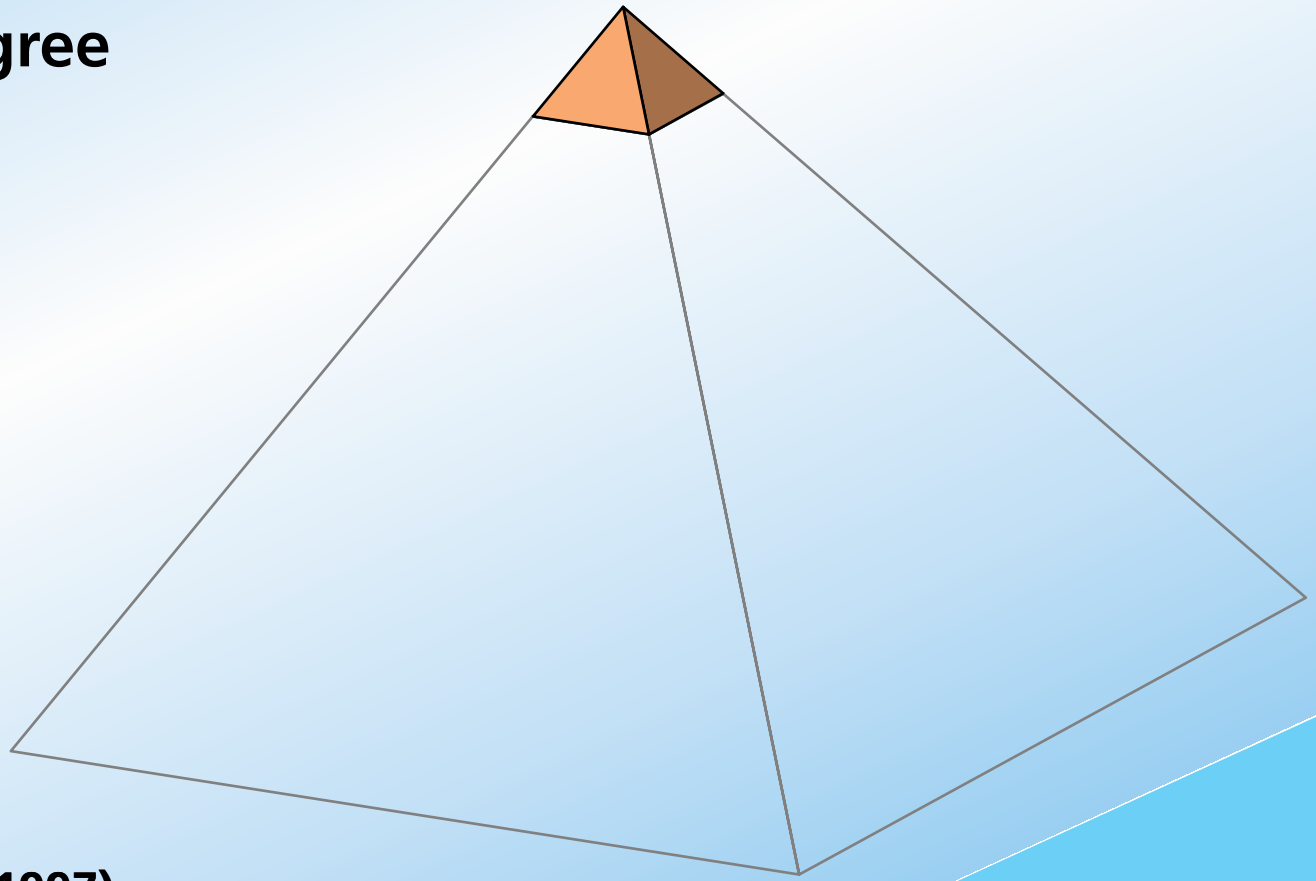
**in physics**



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

# *We have a problem*

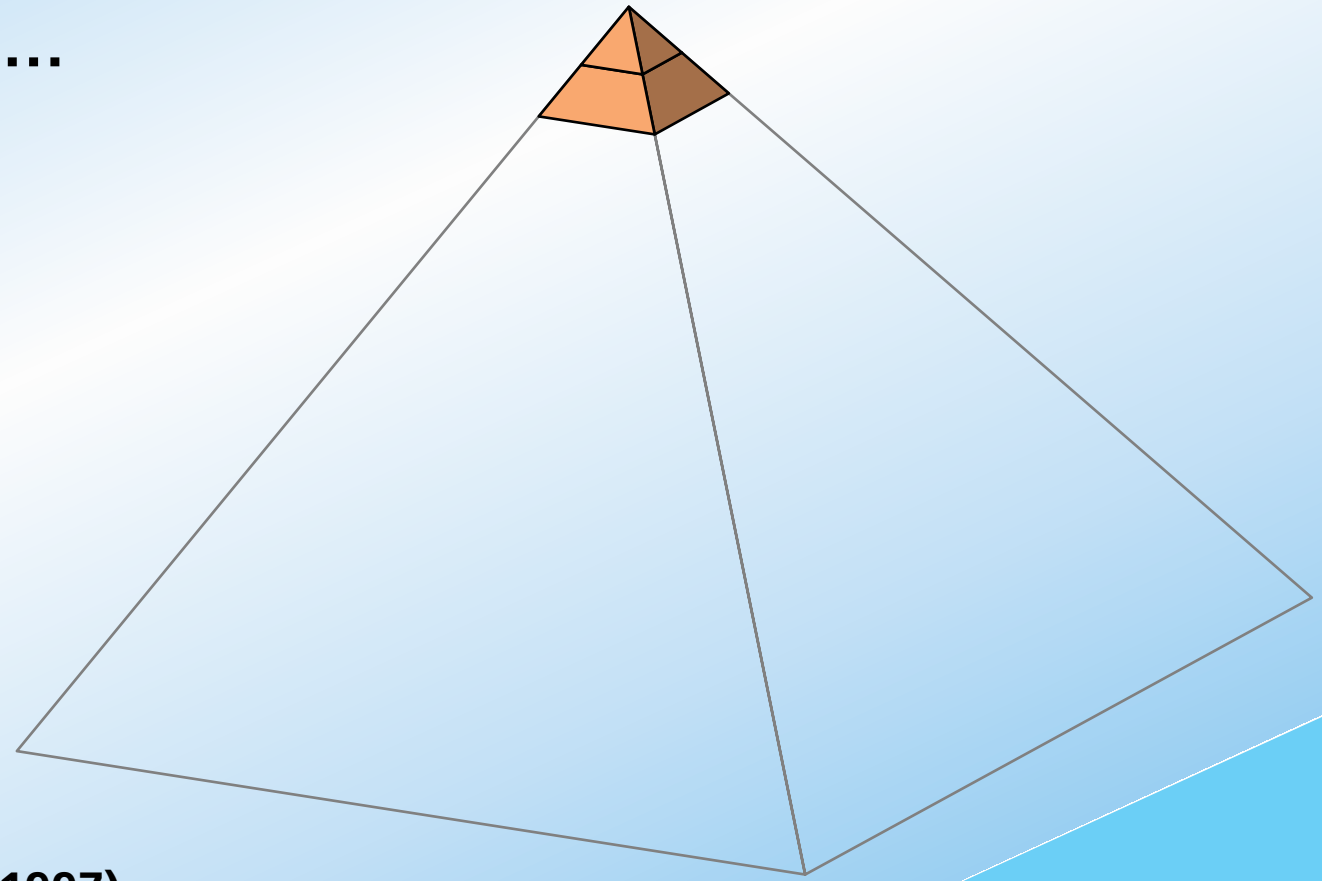
**Of the 4,300 students with a bachelor's degree in physics…**



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

# *We have a problem*

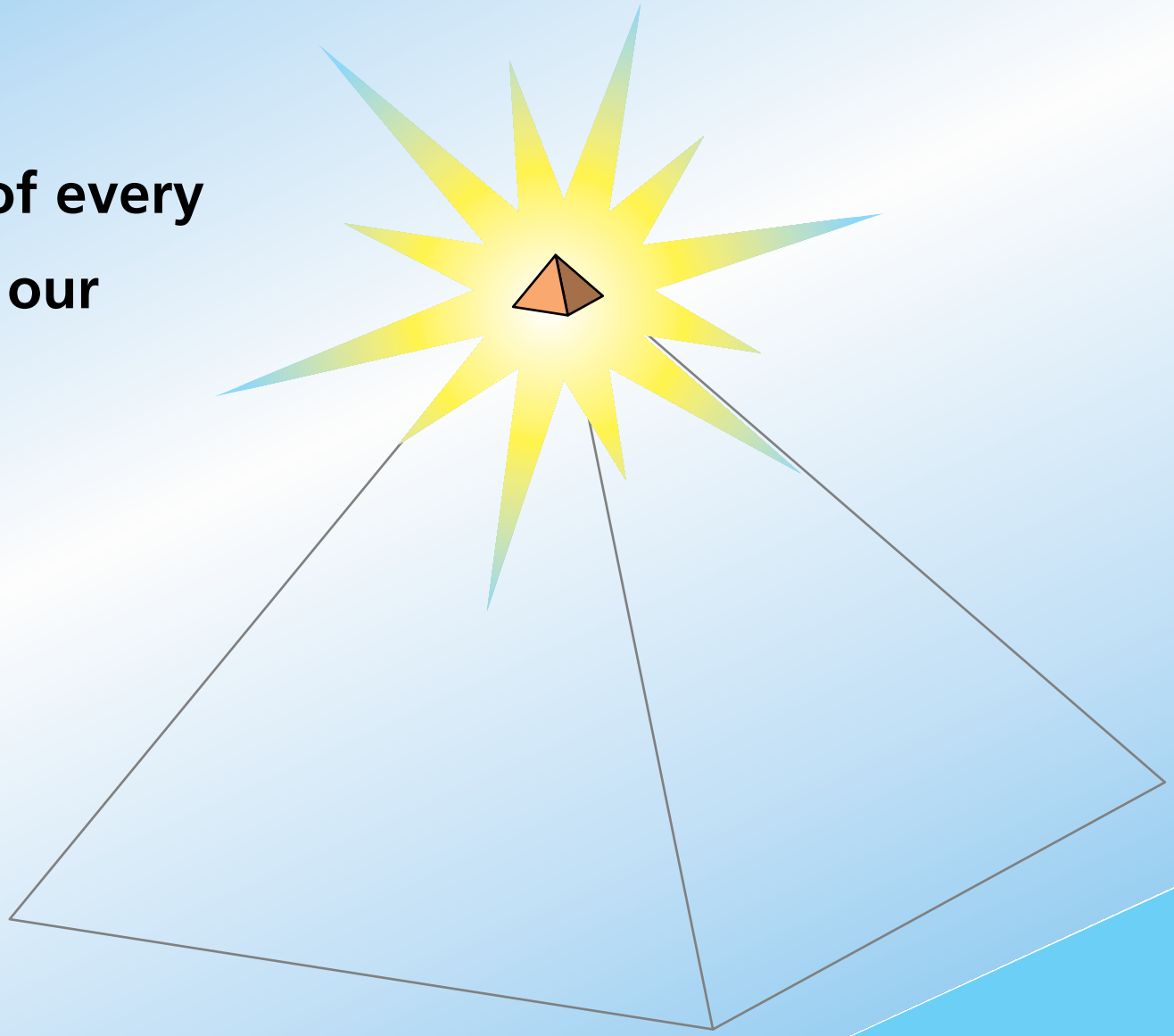
**about 35% go on to get a Ph.D. in physics…**



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

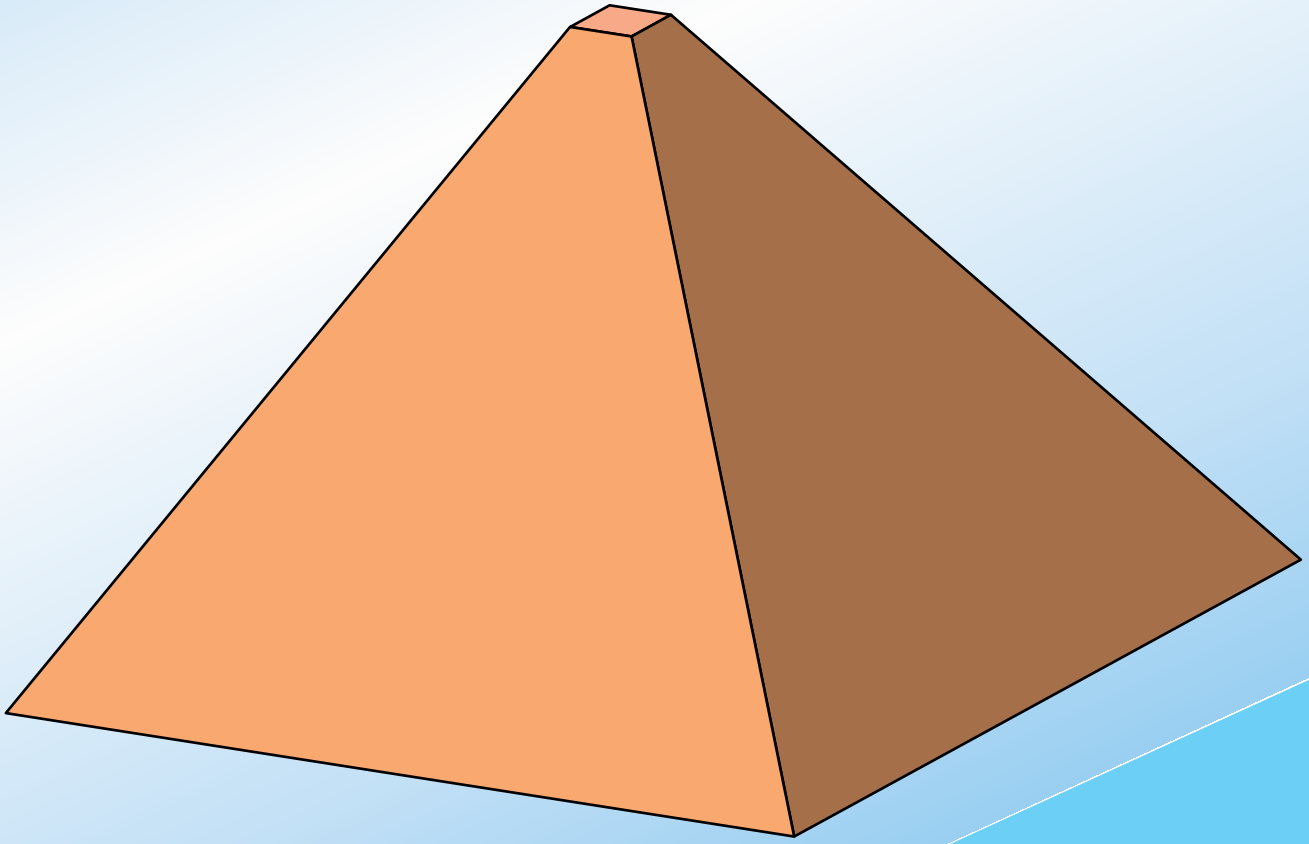
# *We have a problem*

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



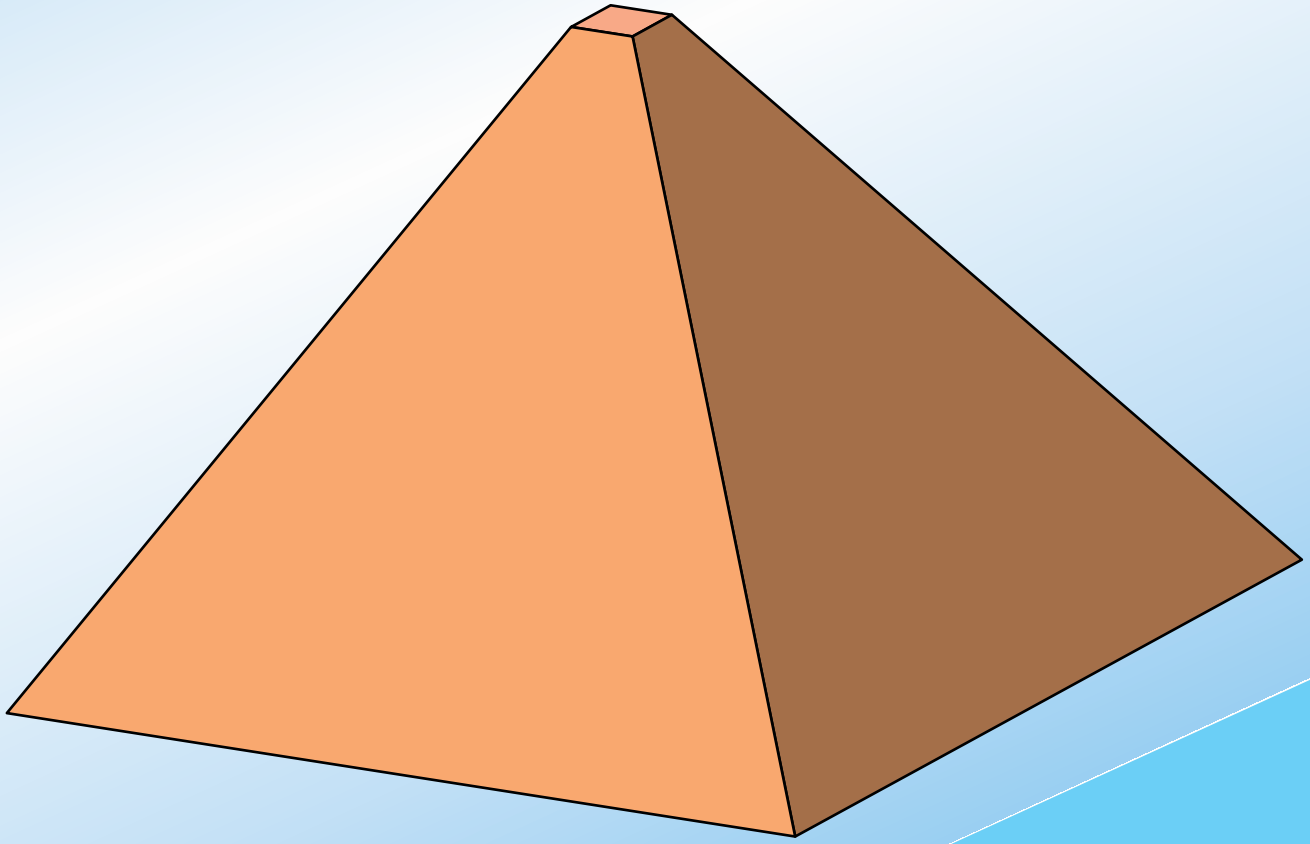
# *We have a problem*

**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 transparence 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 transparence 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*?"**

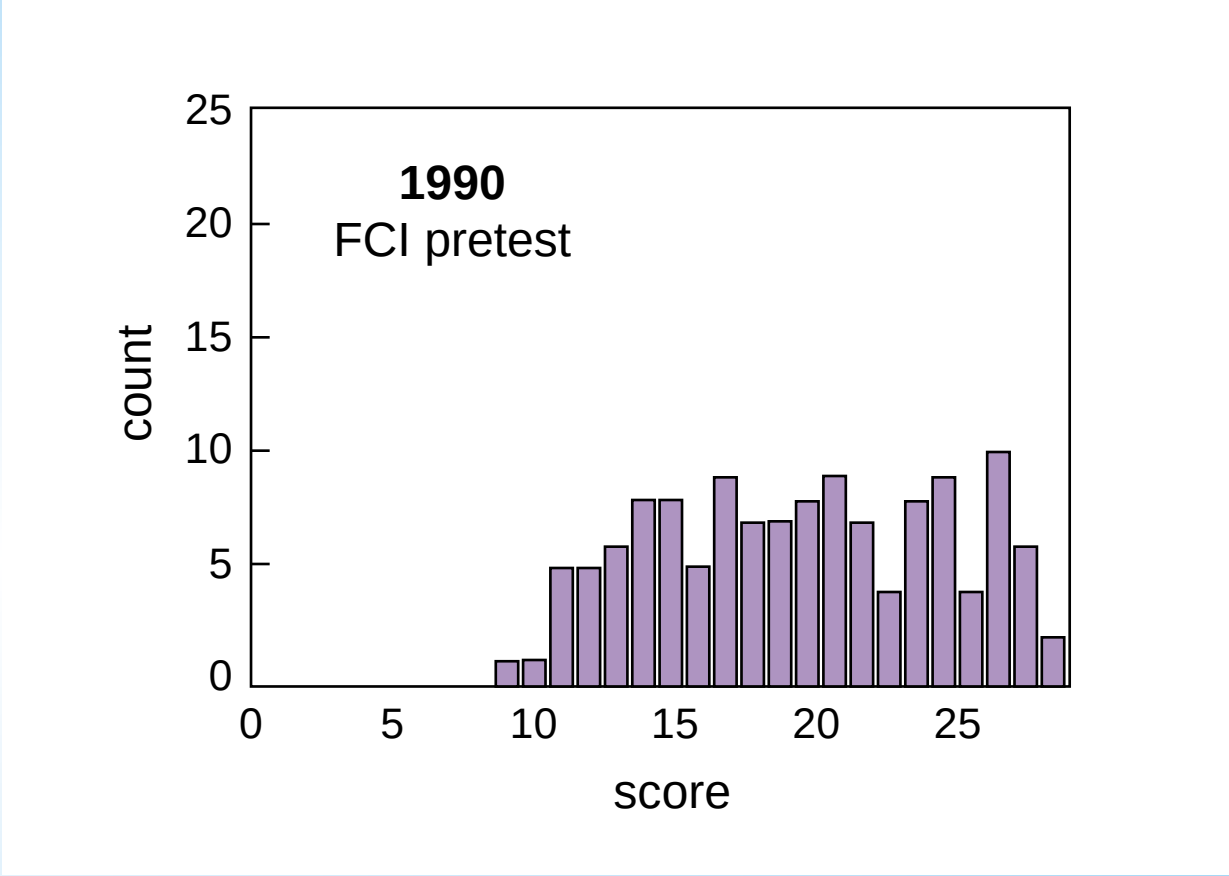

Why do we have this problem?

# *Why do we have this problem?*

**Lectures focus on transfer of information…**

# *Why do we have this problem?*

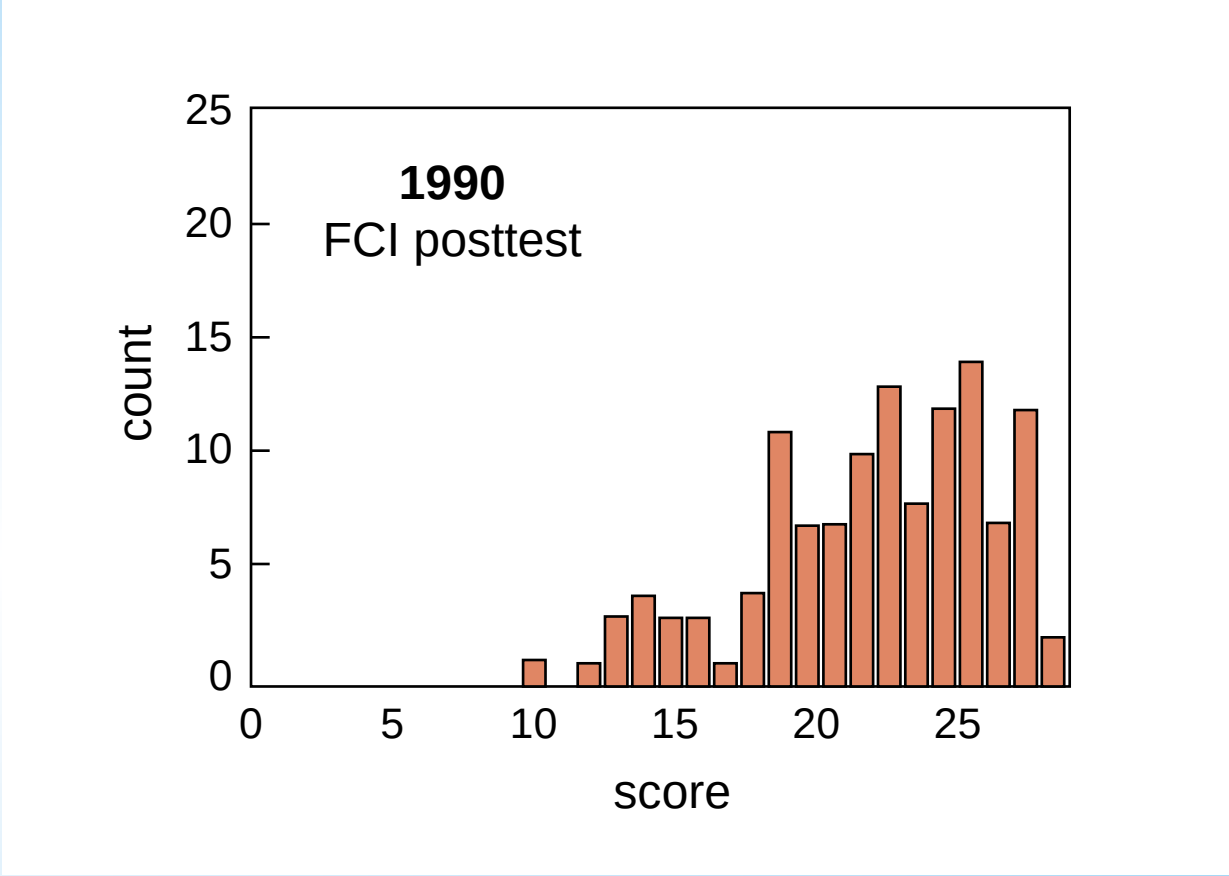
## …but physics is not just information!




**Hestenes, *et al.*, *TPT* 30, 141 (1992)**

# *Why do we have this problem?*

**…but physics is not just information!**



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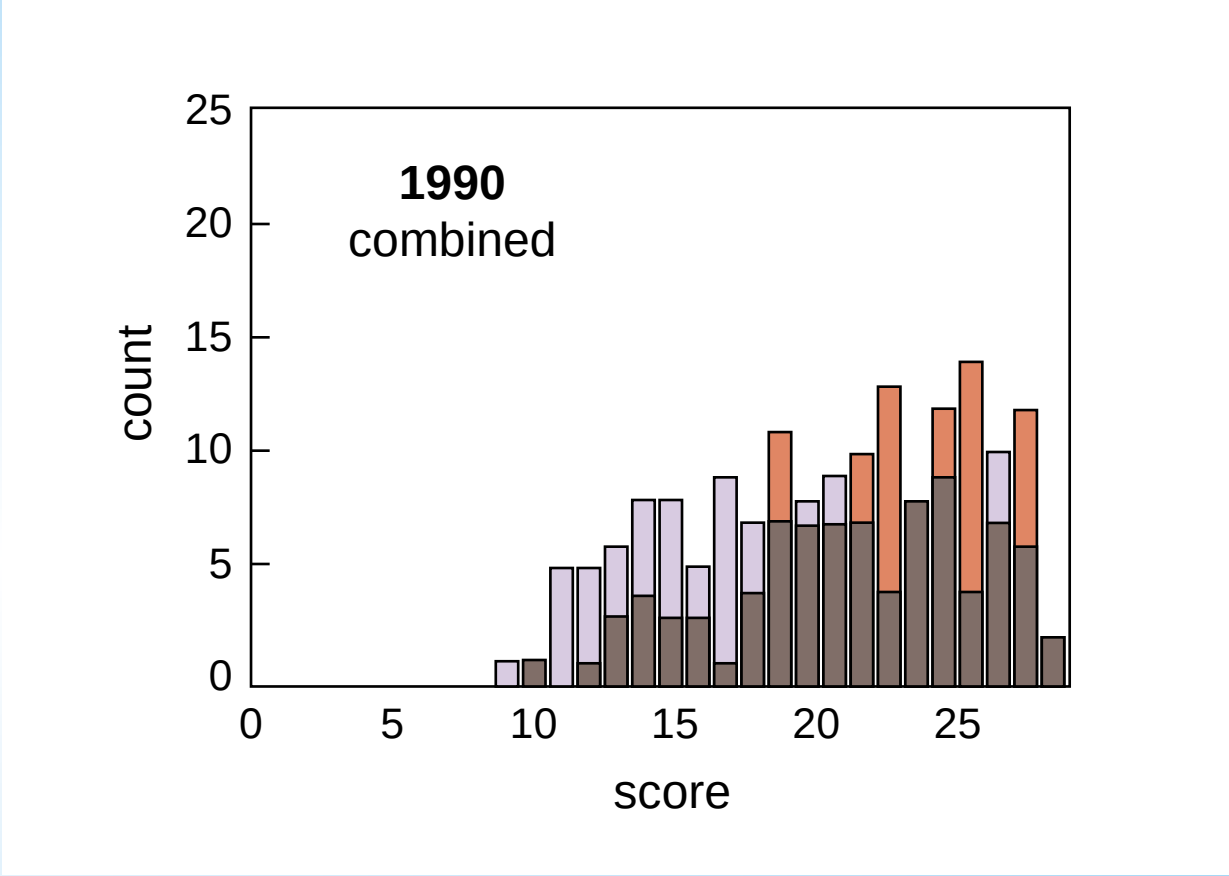

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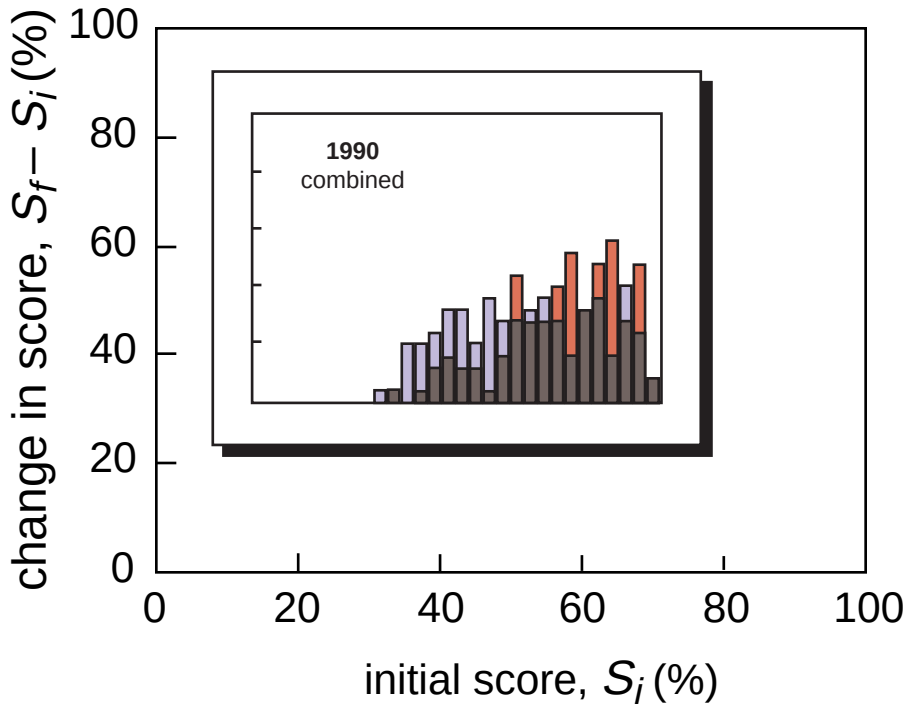

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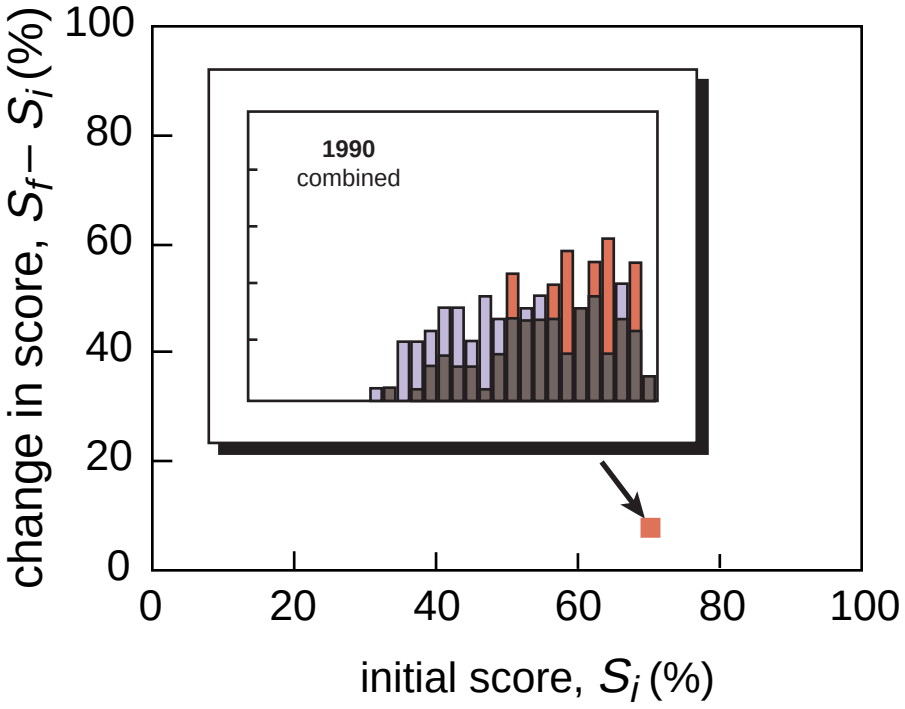

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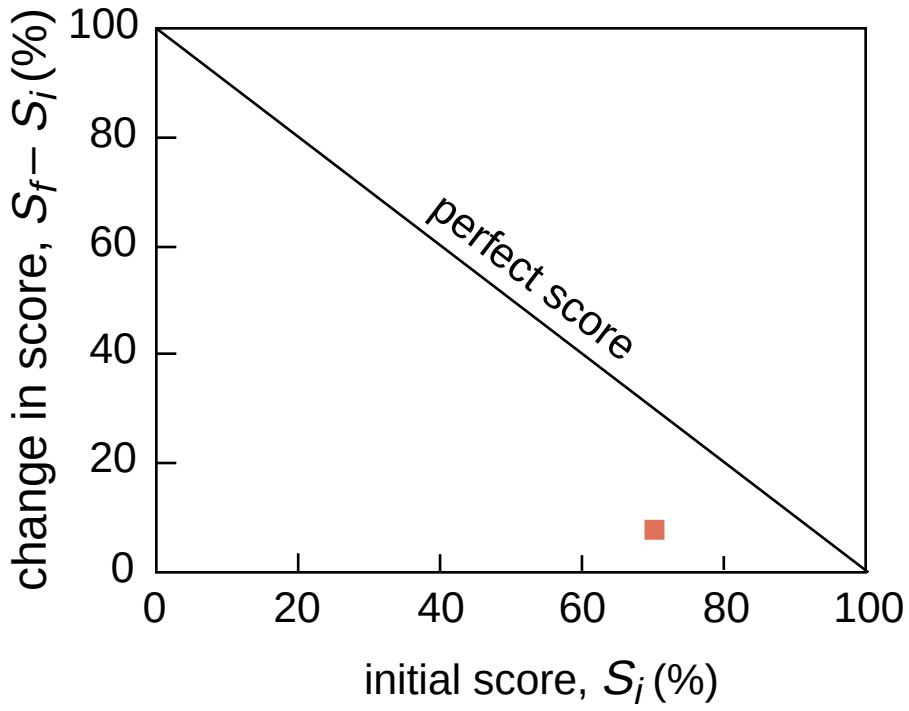

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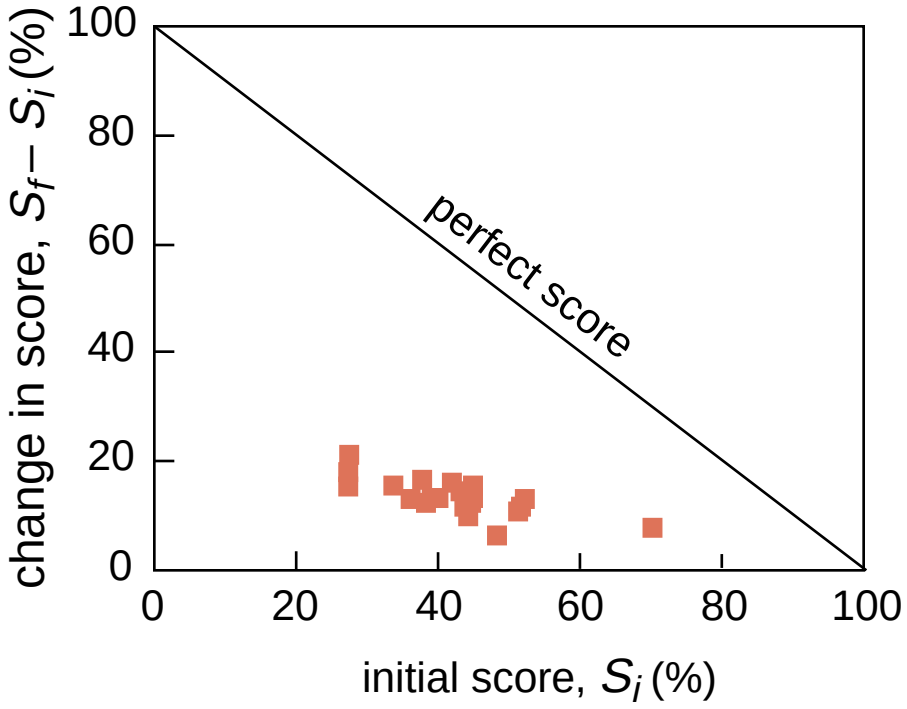

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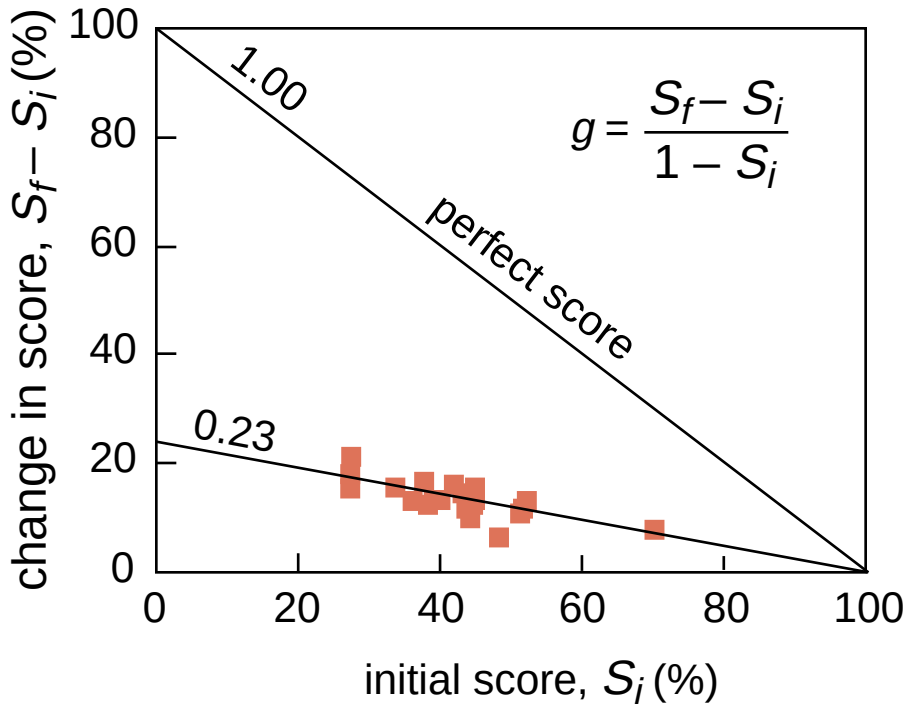

# *Why do we have this problem?*

**Conventional problems reinforce bad study habits**

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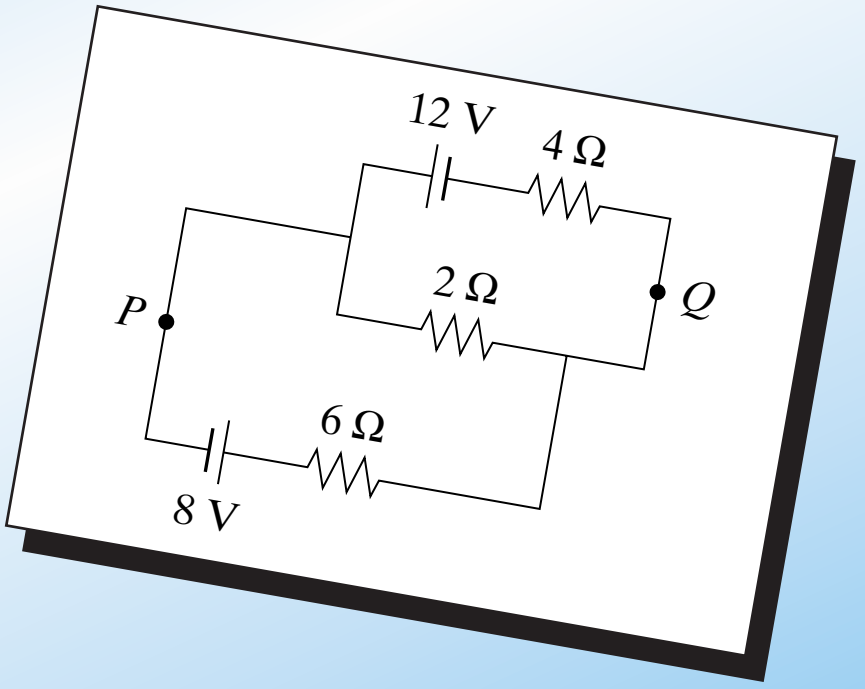


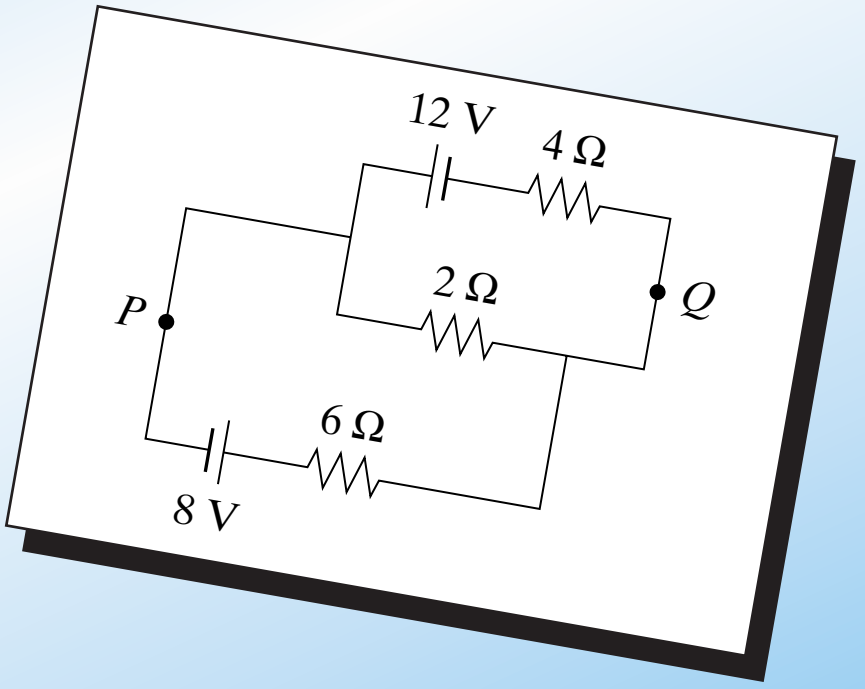
# *Why do we have this problem?*

## Conventional problems reinforce bad study habits

**Calculate:**

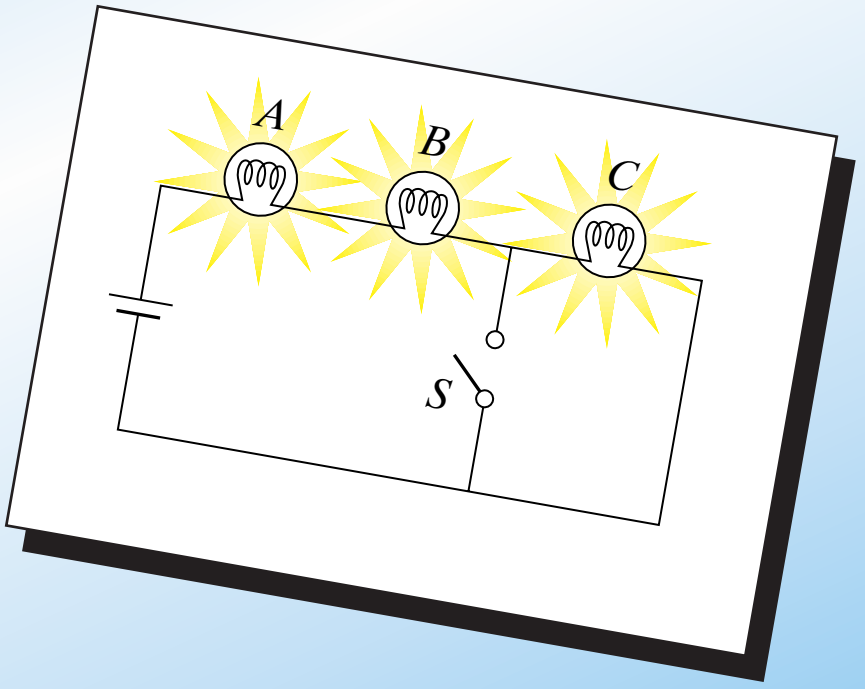
**(*a*) the current in the 2-Ω resistor, and**

**(*b*) the potential difference between points *P* and *Q***



# *Why do we have this problem?*

**Are basic principles understood?**

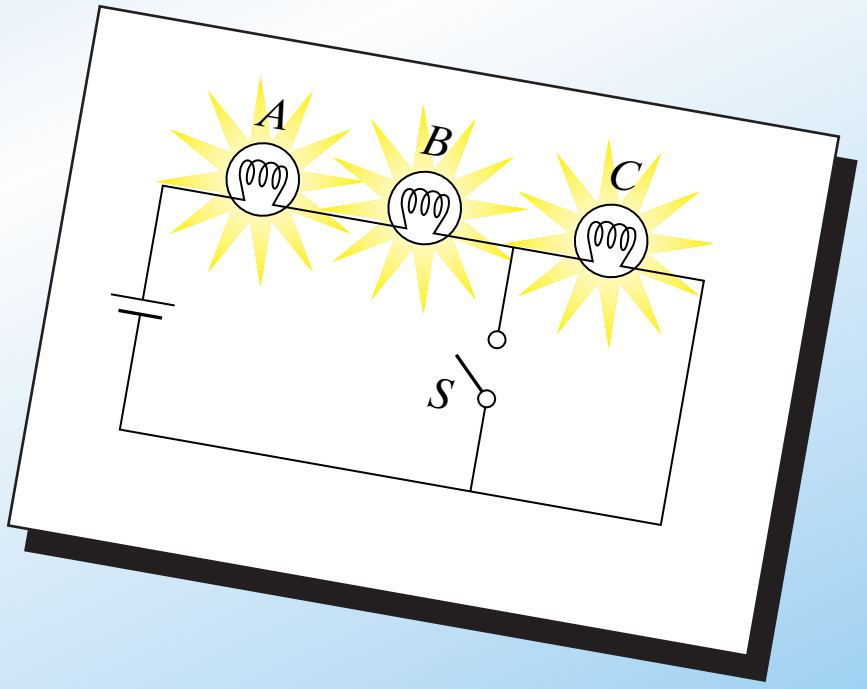


# *Why do we have this problem?*

## 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?**



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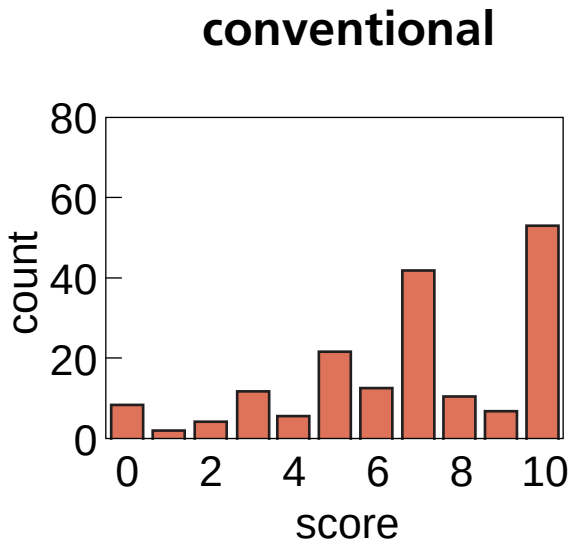


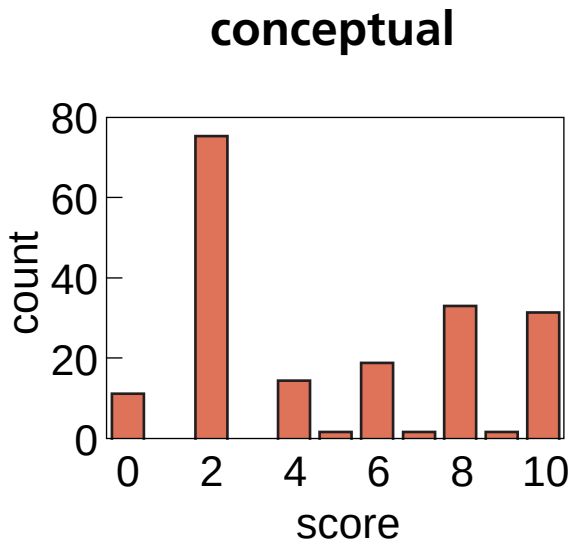

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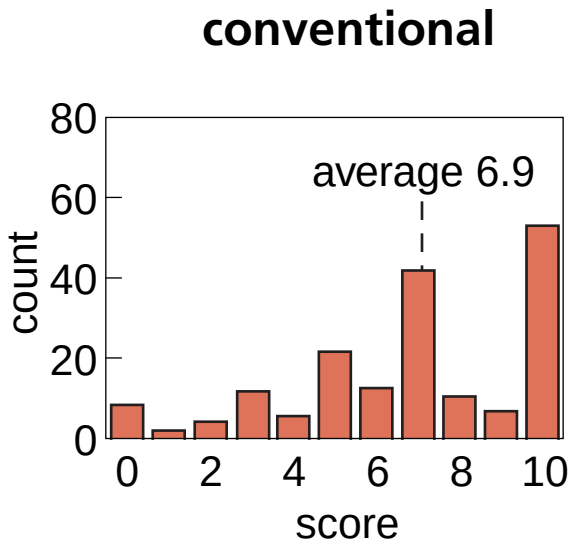


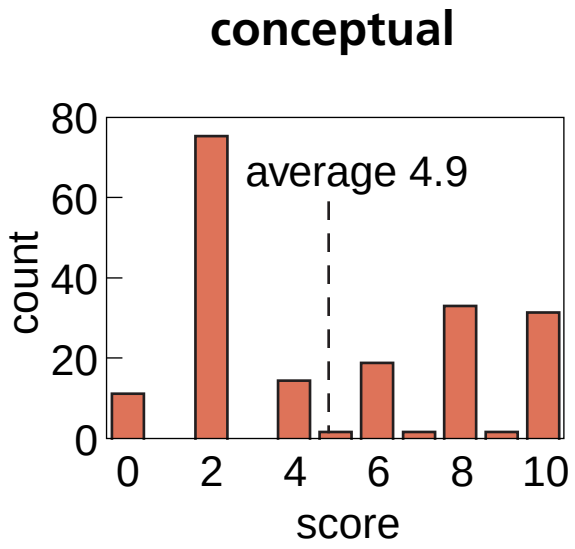

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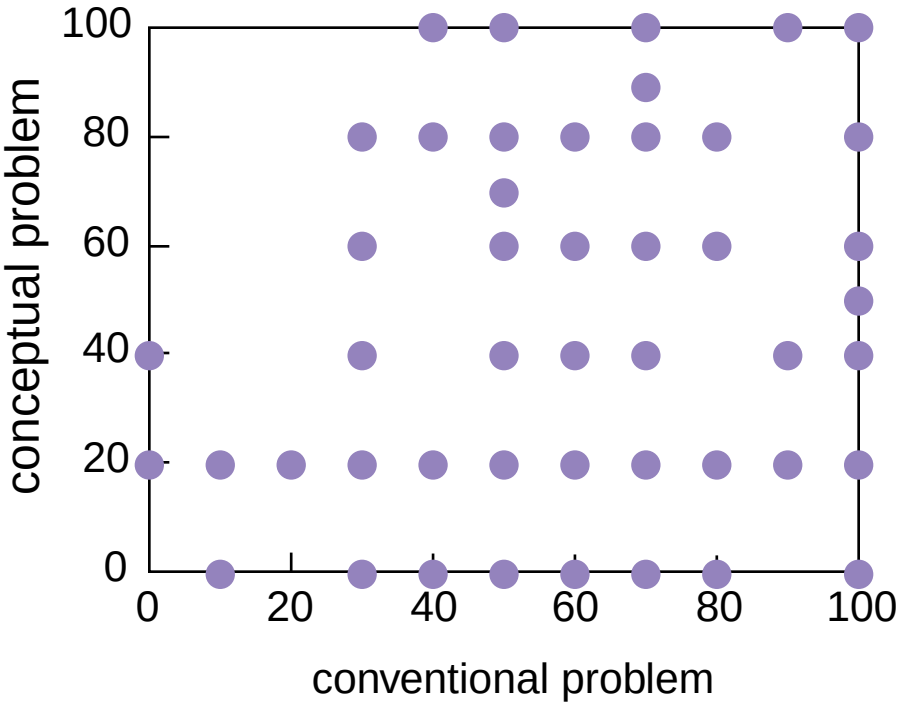

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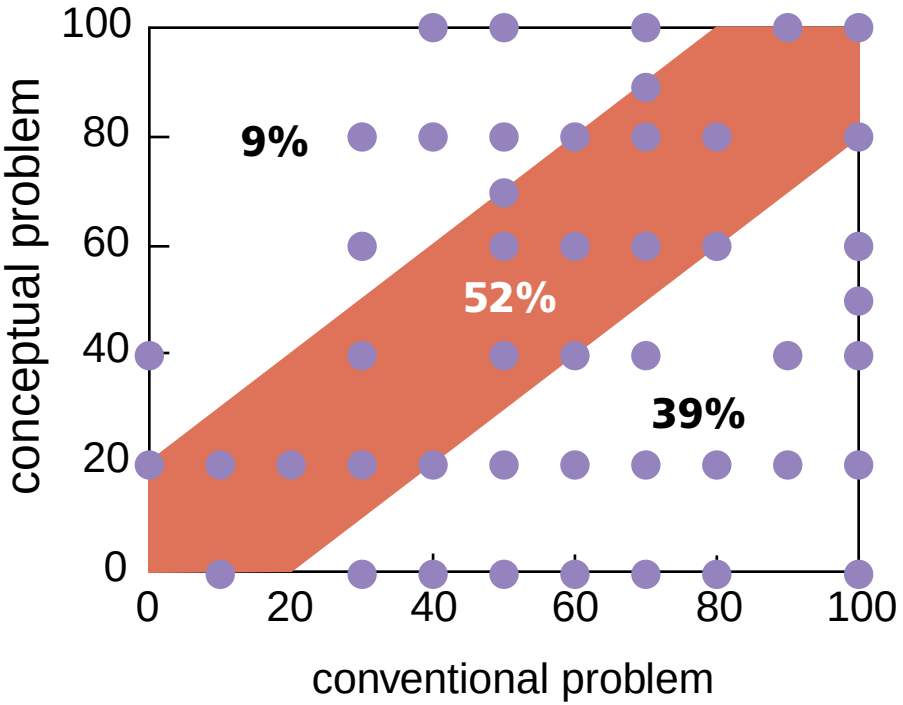



So what should we do?

# *Peer Instruction*

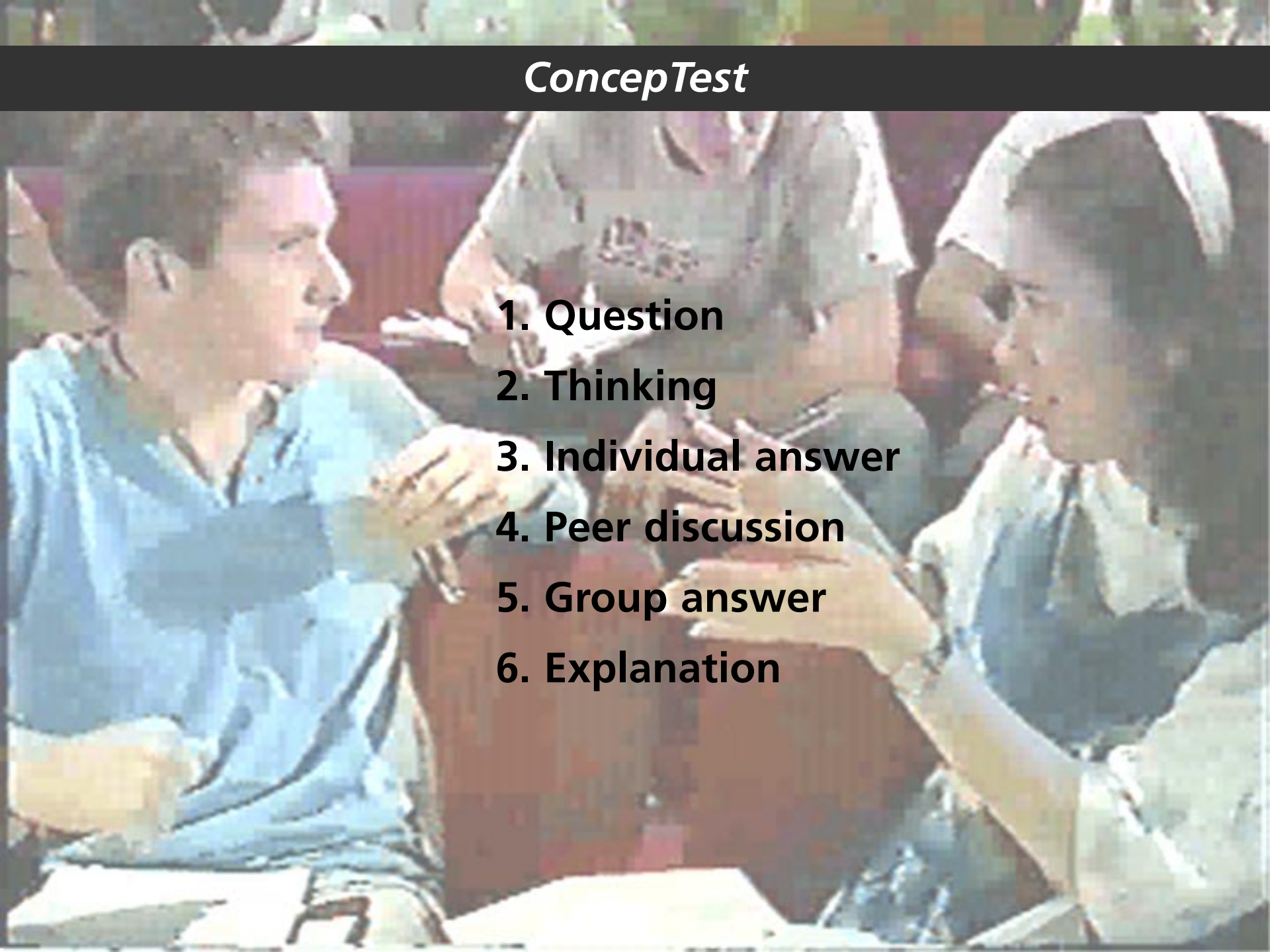
**Help students take more responsibility for learning!**

# *Peer Instruction*

**Main features:**

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

# *ConcepTest*



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

# *Is it any good?*

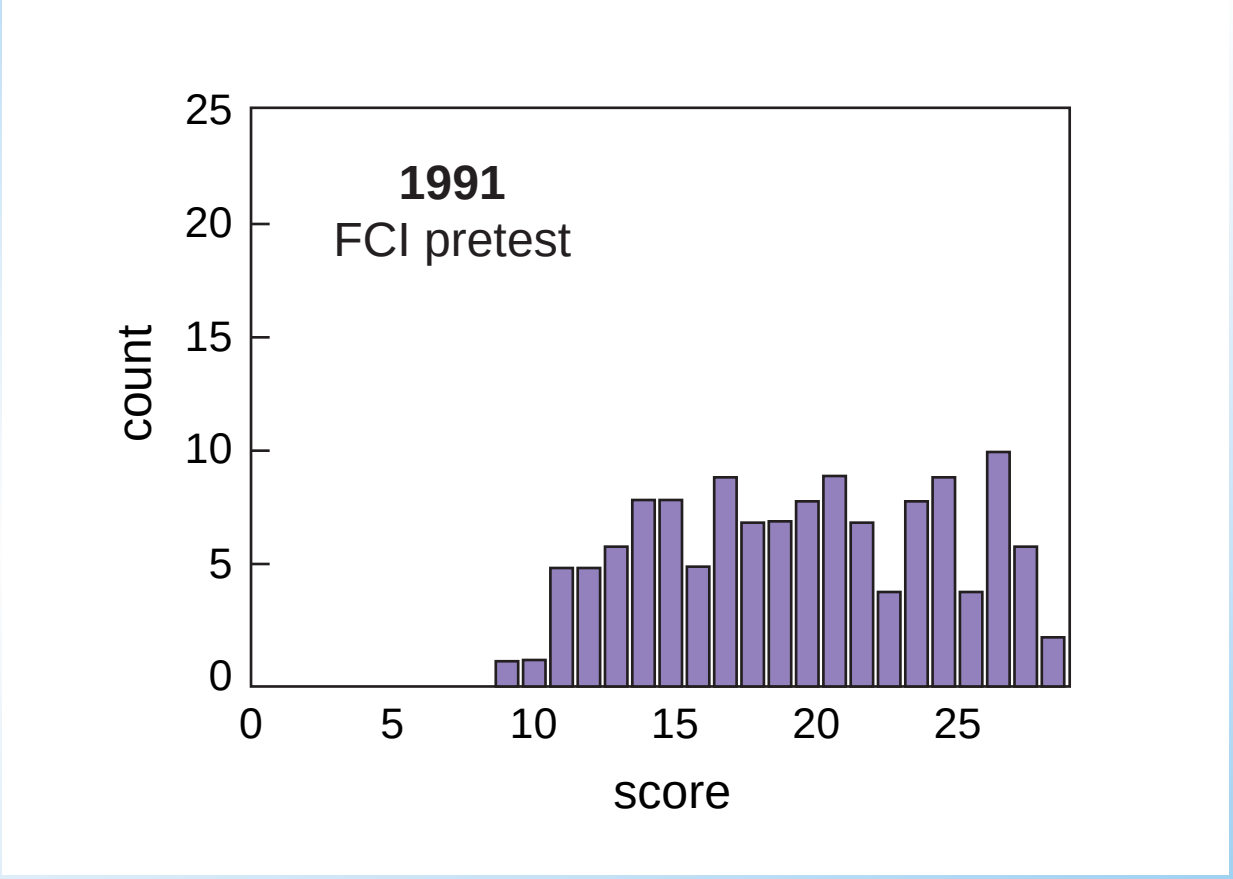
# *Is it any good?*

- **Results**

# *Is it any good?*

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

# *Results*



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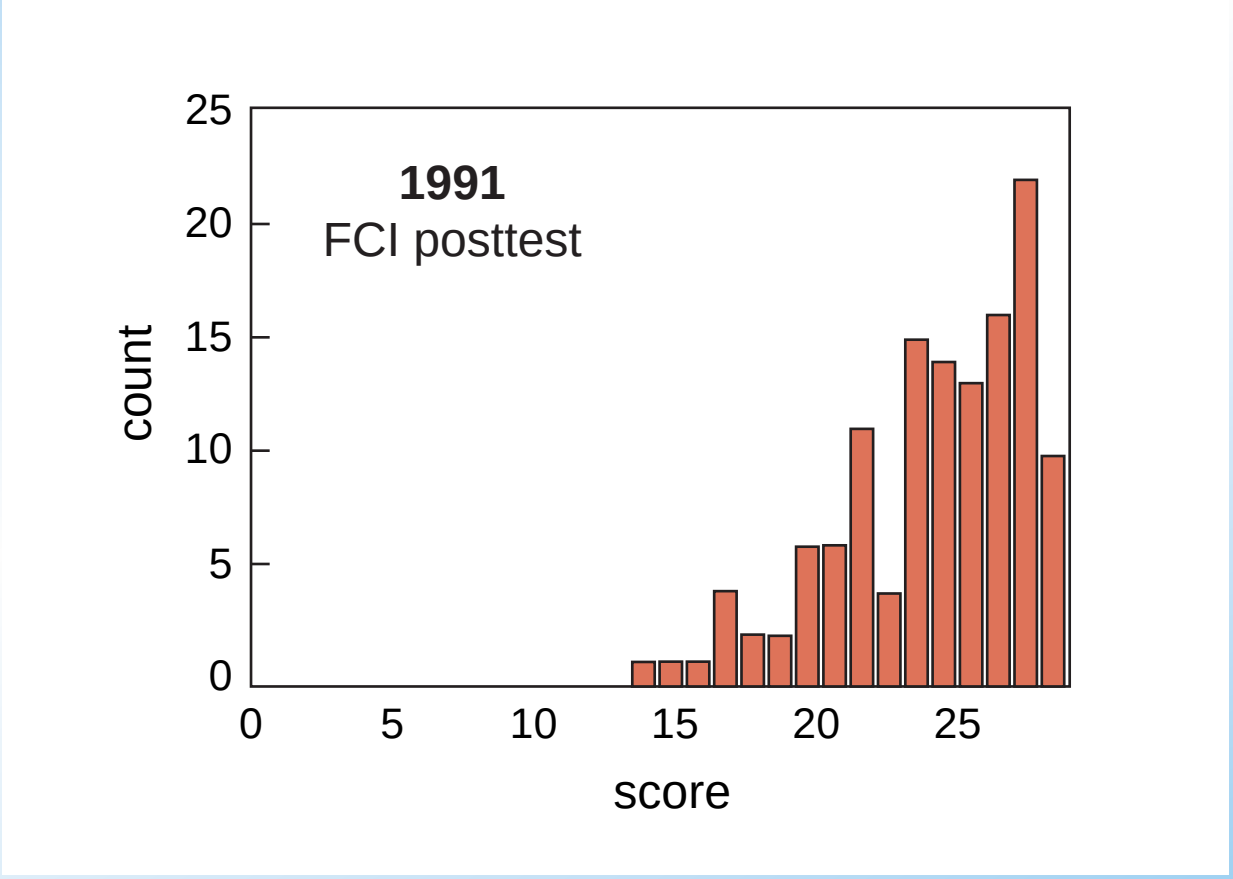

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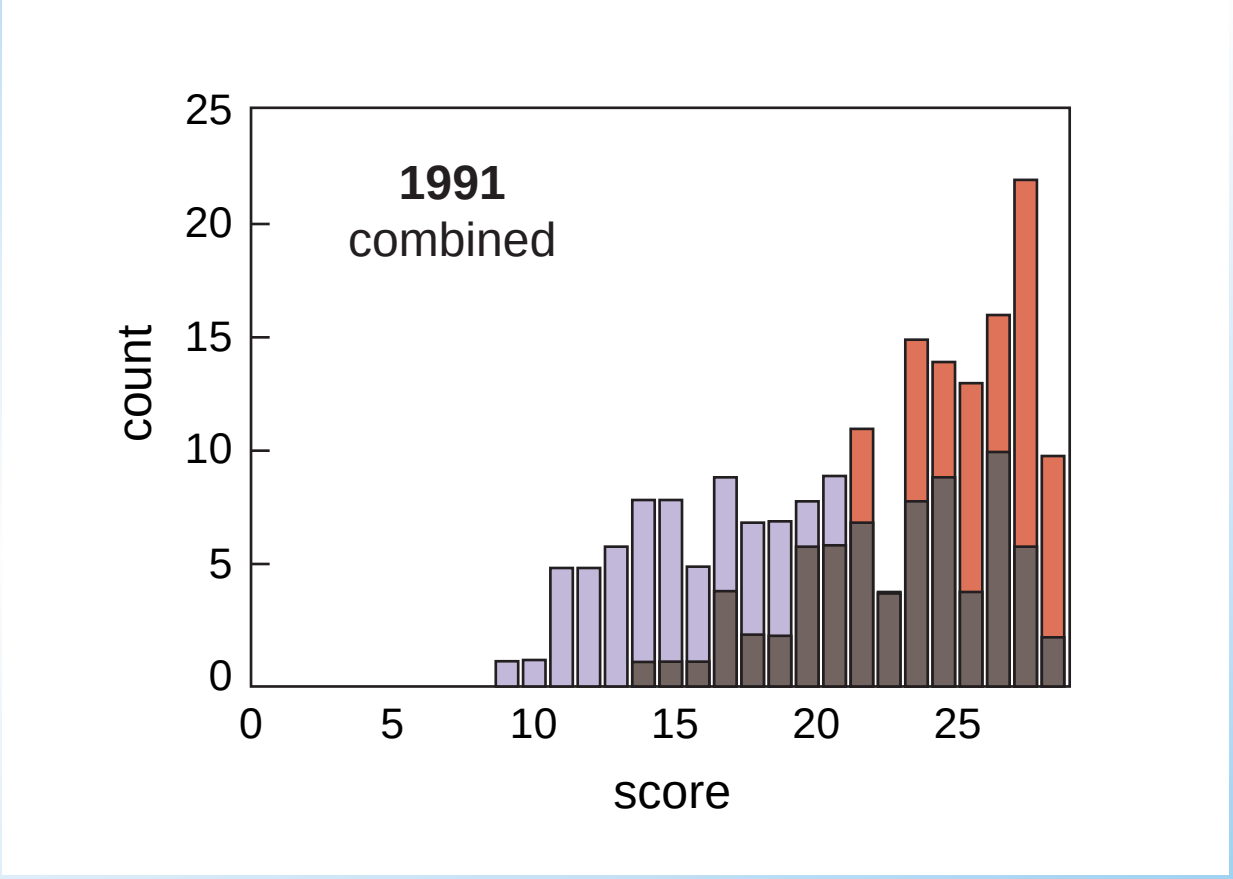

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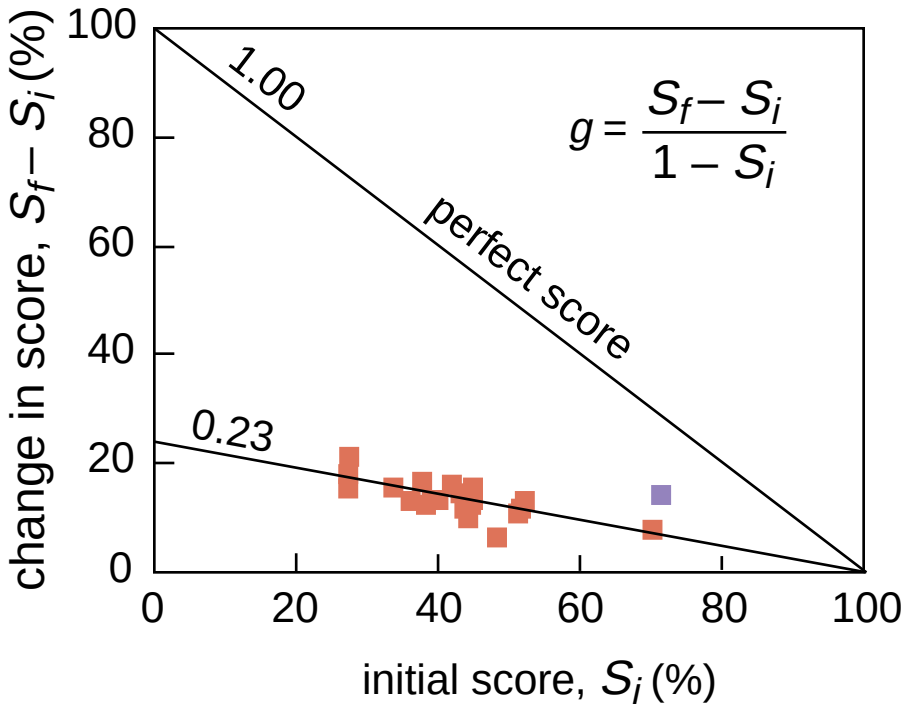
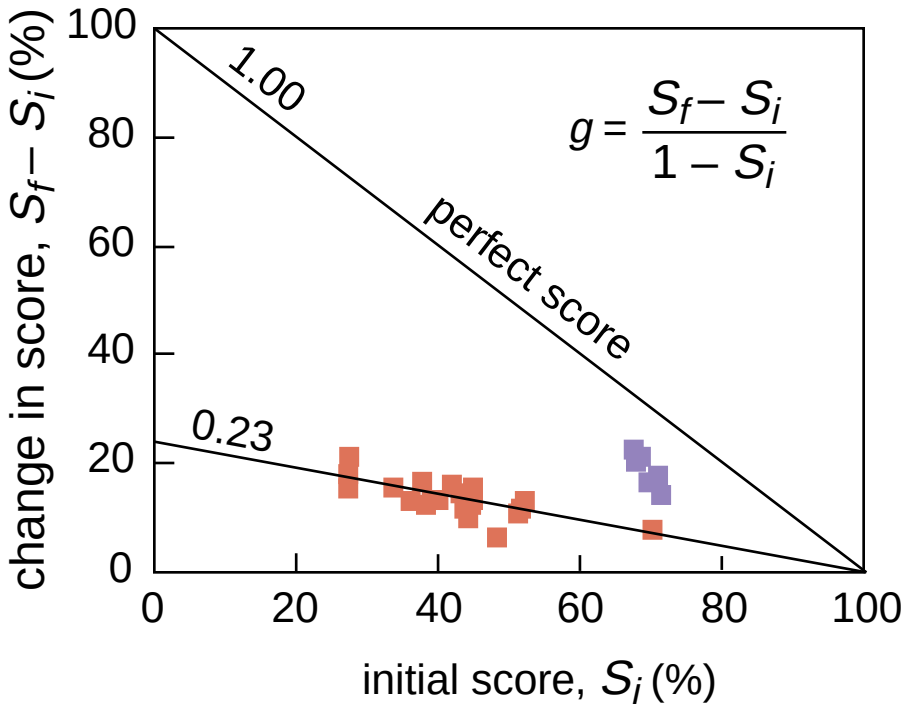

change in score, $S_f - S_i$ (%)
initial score, $S_i$ (%)
0
20
40
60
80
100
1.00
perfect score
0.23
$g = \frac{S_f - S_i}{1 - S_i}$

# Results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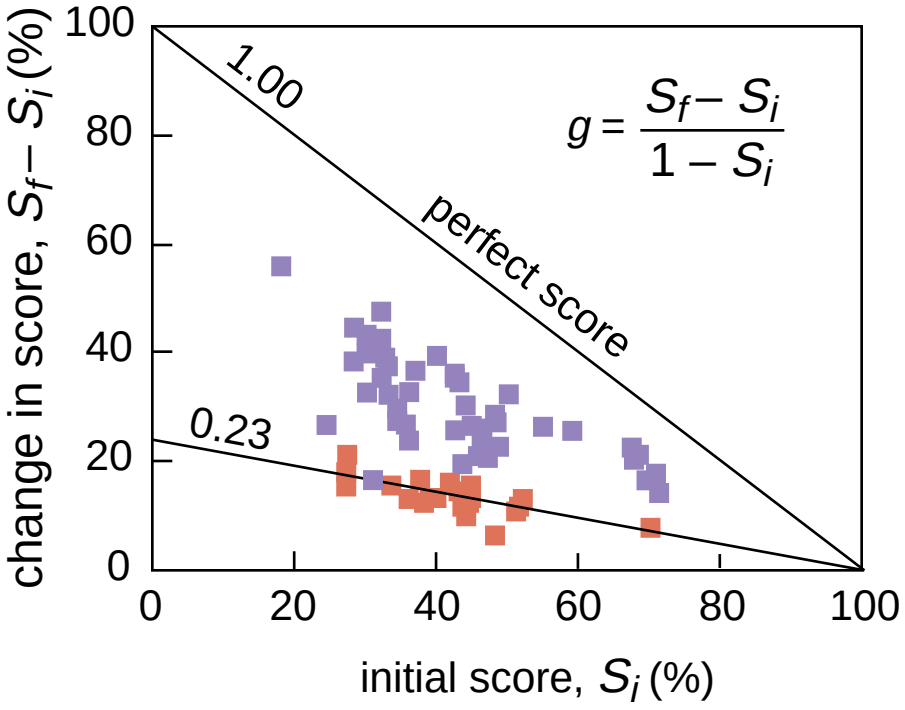
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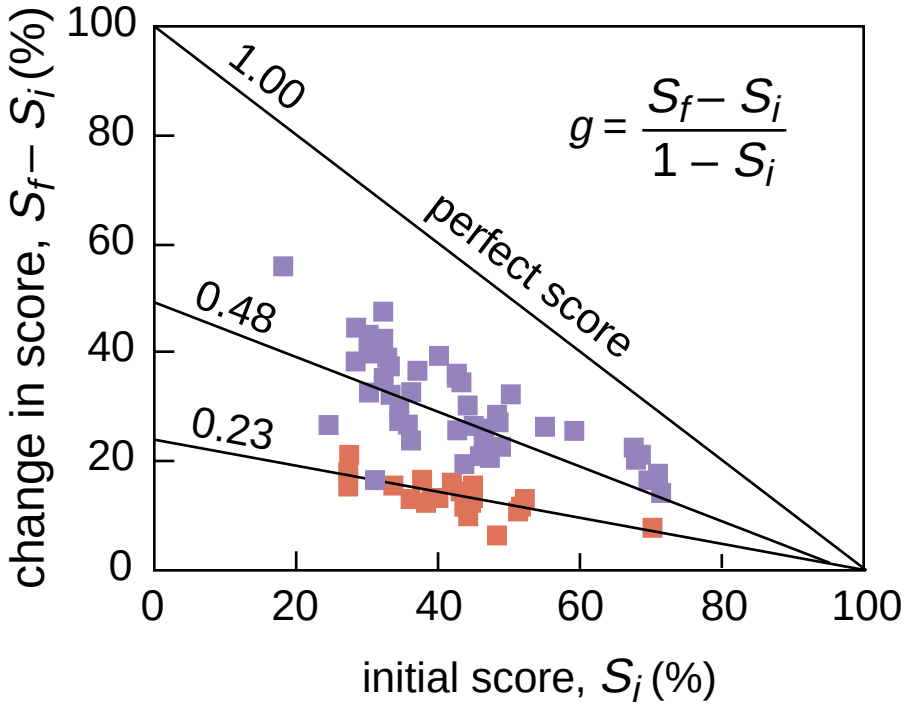
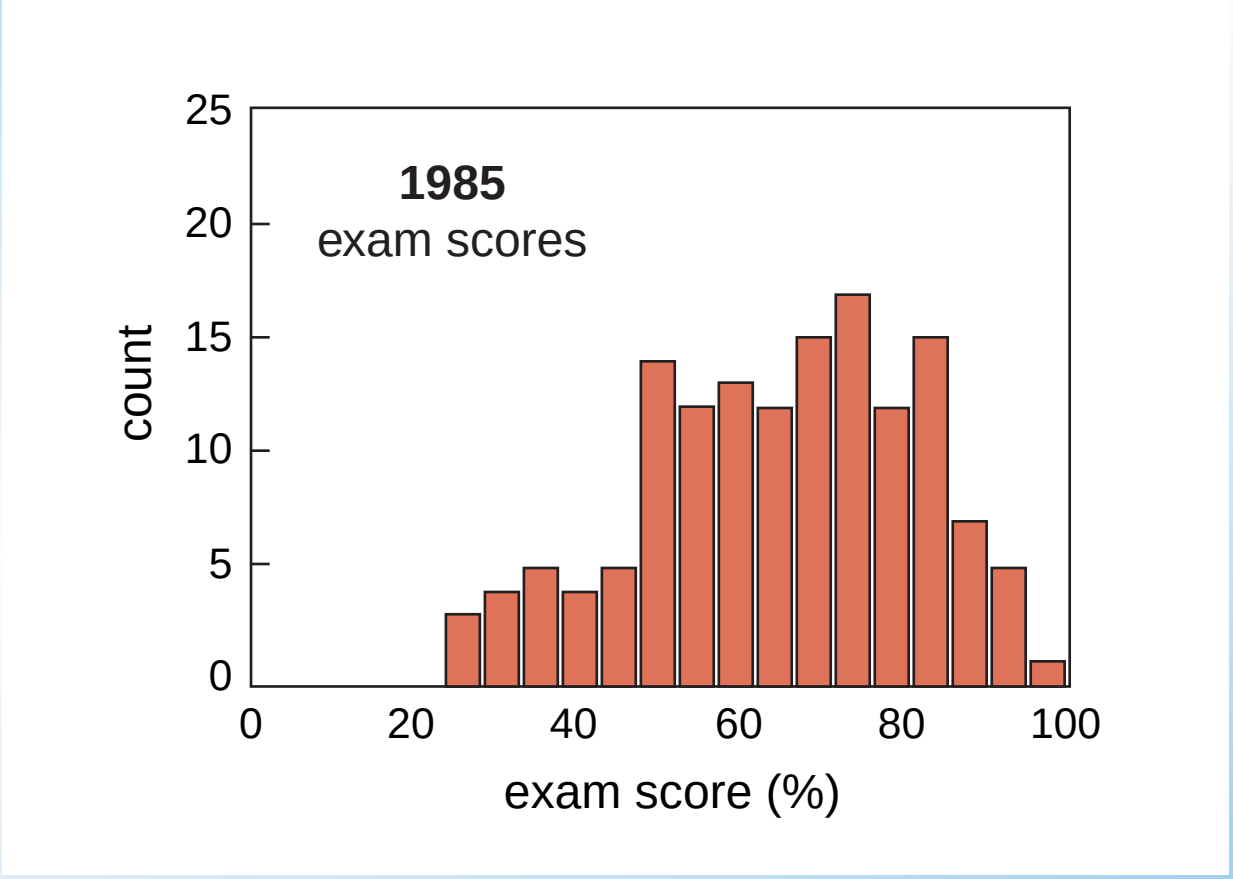

change in score, $S_f - S_i$ (%)
initial score, $S_i$ (%)
0
20
40
60
80
100
1.00
perfect score
0.48
0.23
$g = \frac{S_f - S_i}{1 - S_i}$

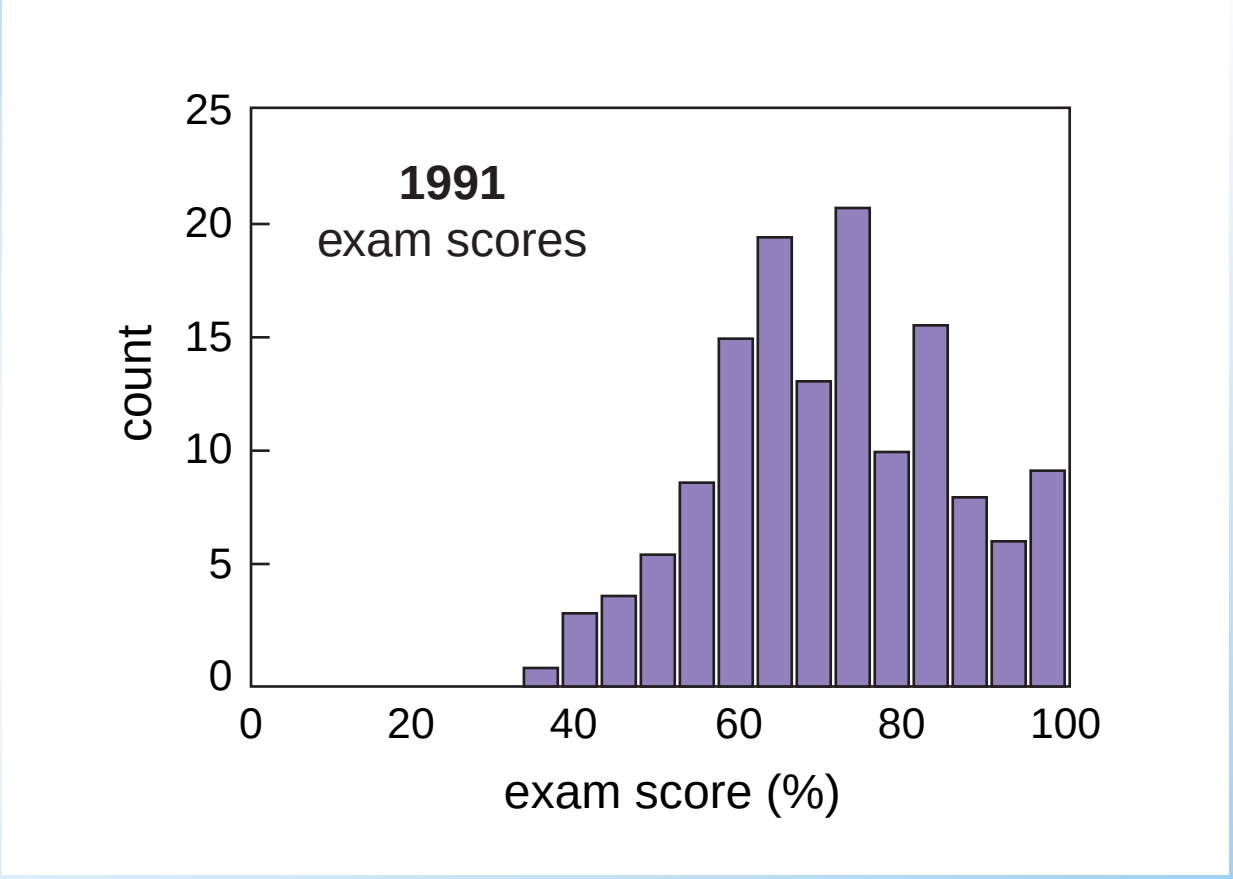
# *Results*

**What about problem solving…?**

# *Results*


1985
exam scores
count
25
20
15
10
5
0
0
20
40
60
80
100
exam score (%)

# *Results*


1991
exam scores
count
25
20
15
10
5
0
0
20
40
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80
100
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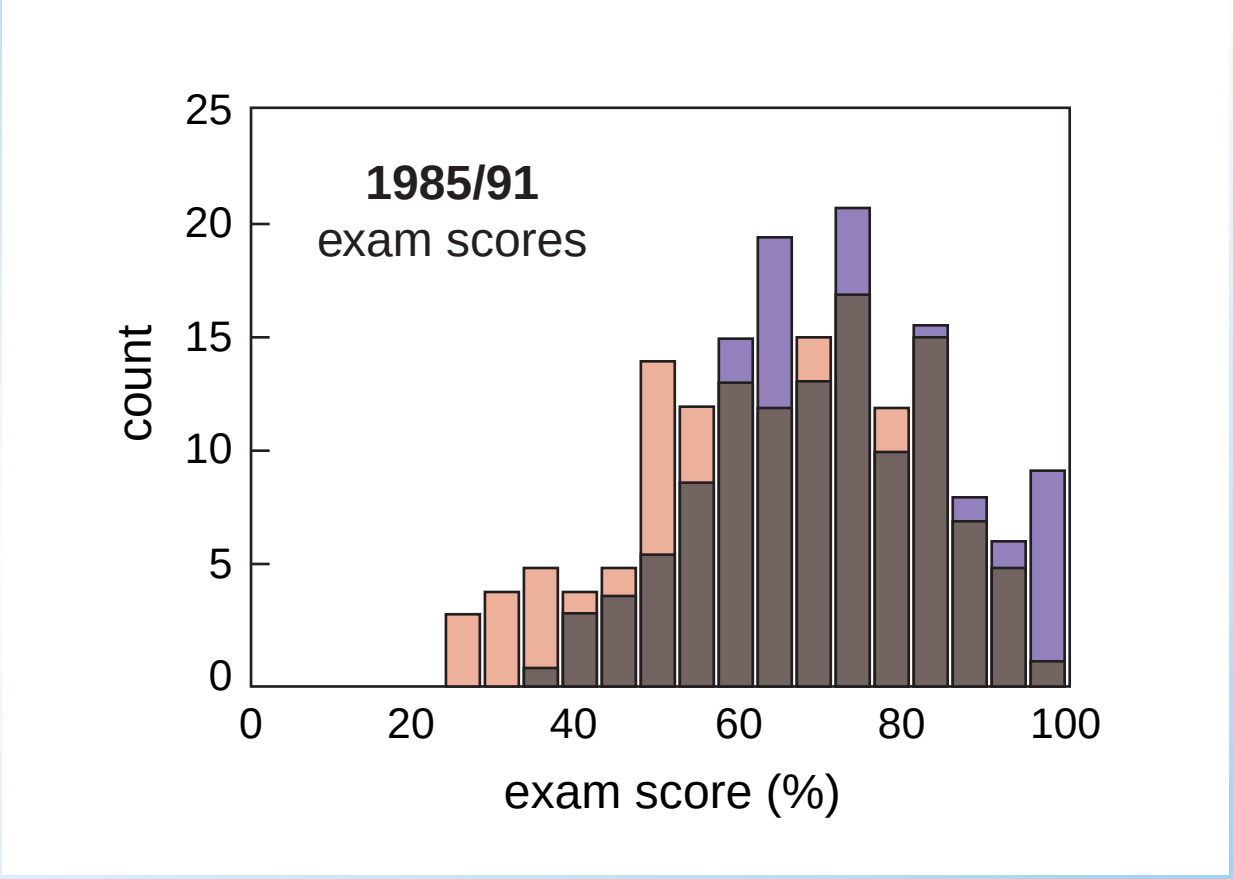
1985/91
exam scores
count
exam score (%)
0
5
10
15
20
25
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20
40
60
80
100

# *Results*

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

# *Results*

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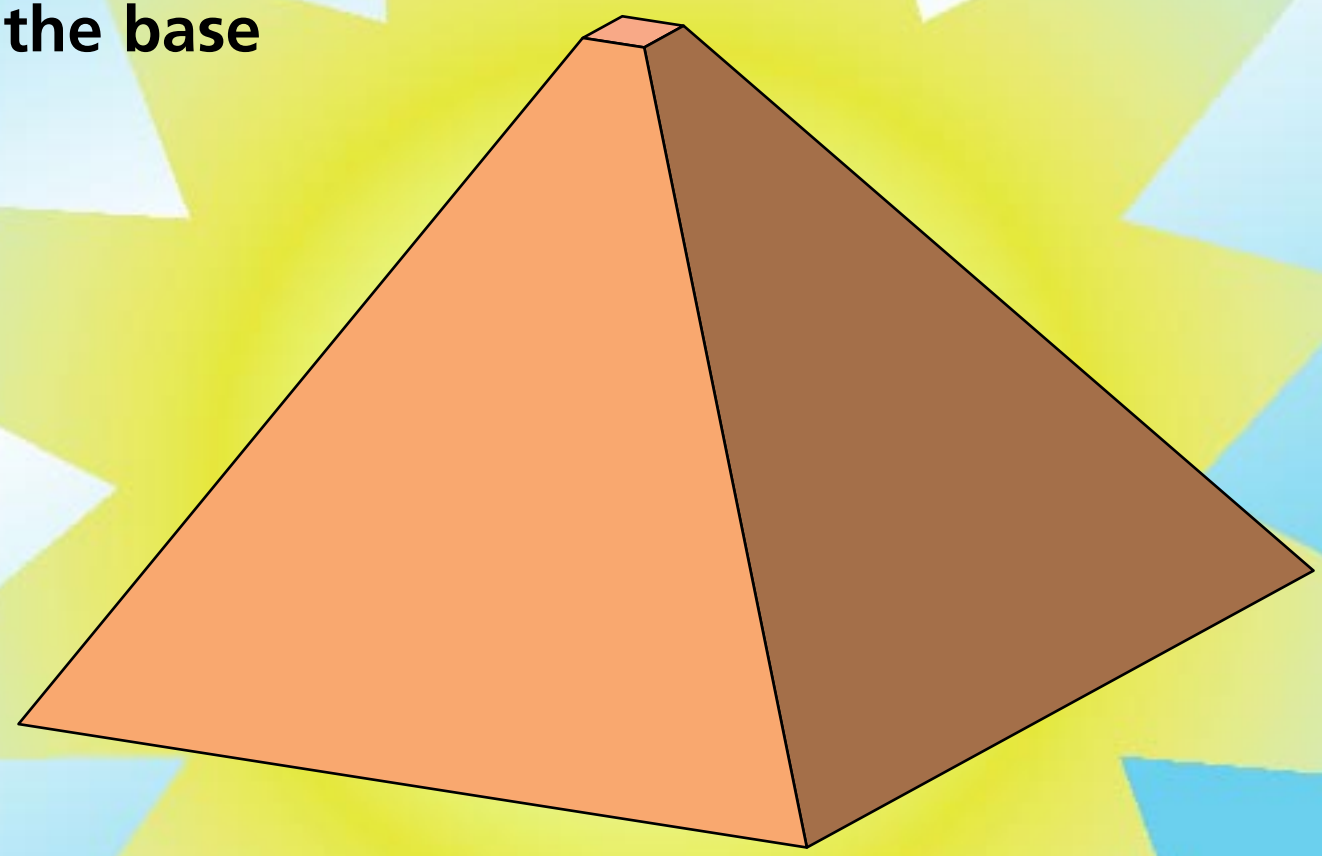
**(but “good” problem solving doesn’t always indicate understanding!)**

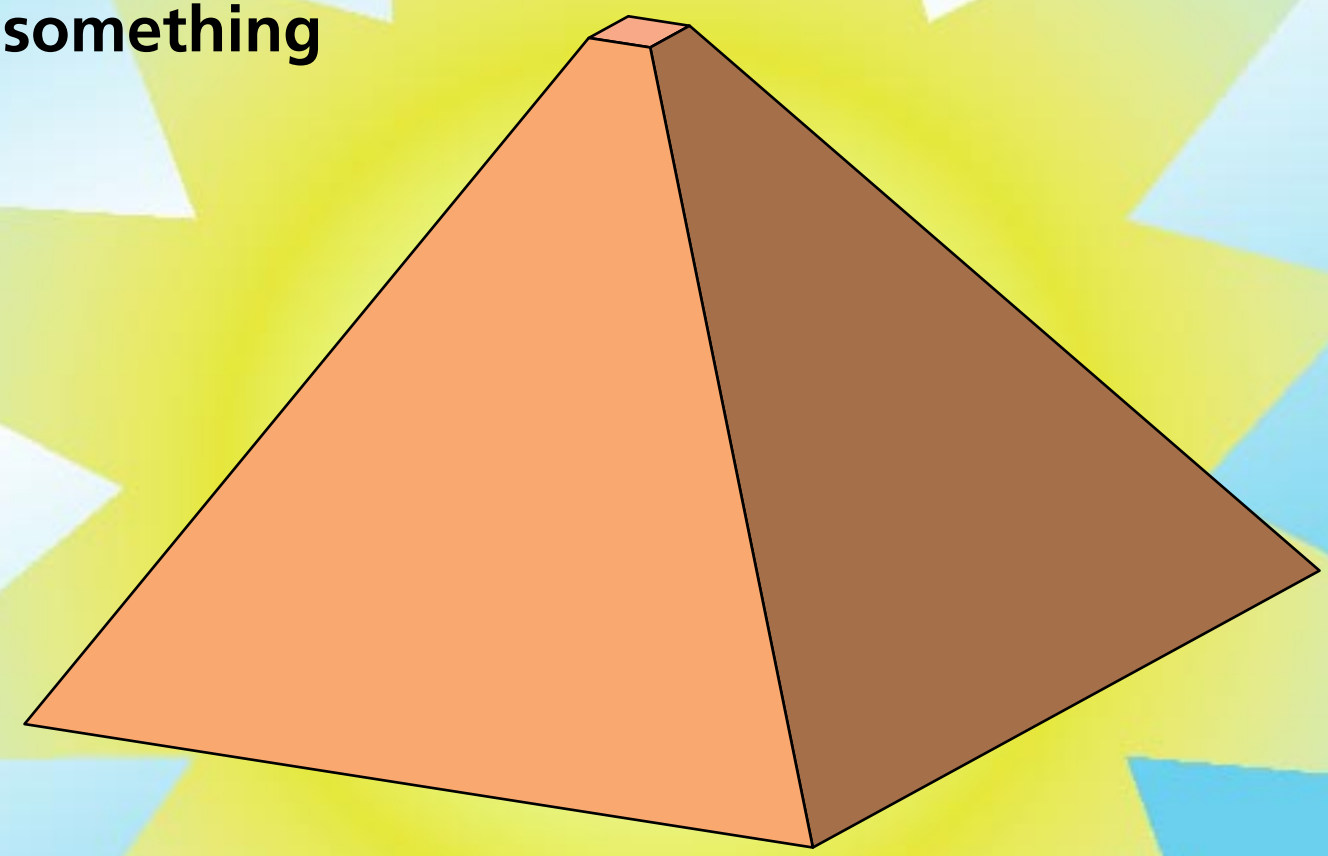
# *Conclusion*

**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**