UNDERSTANDING OR MEMORIZATION: ARE WE TEACHING THE RIGHT THING?

Eric Mazur

MIT
21 September 2000

Outline

- **Problem**

Outline

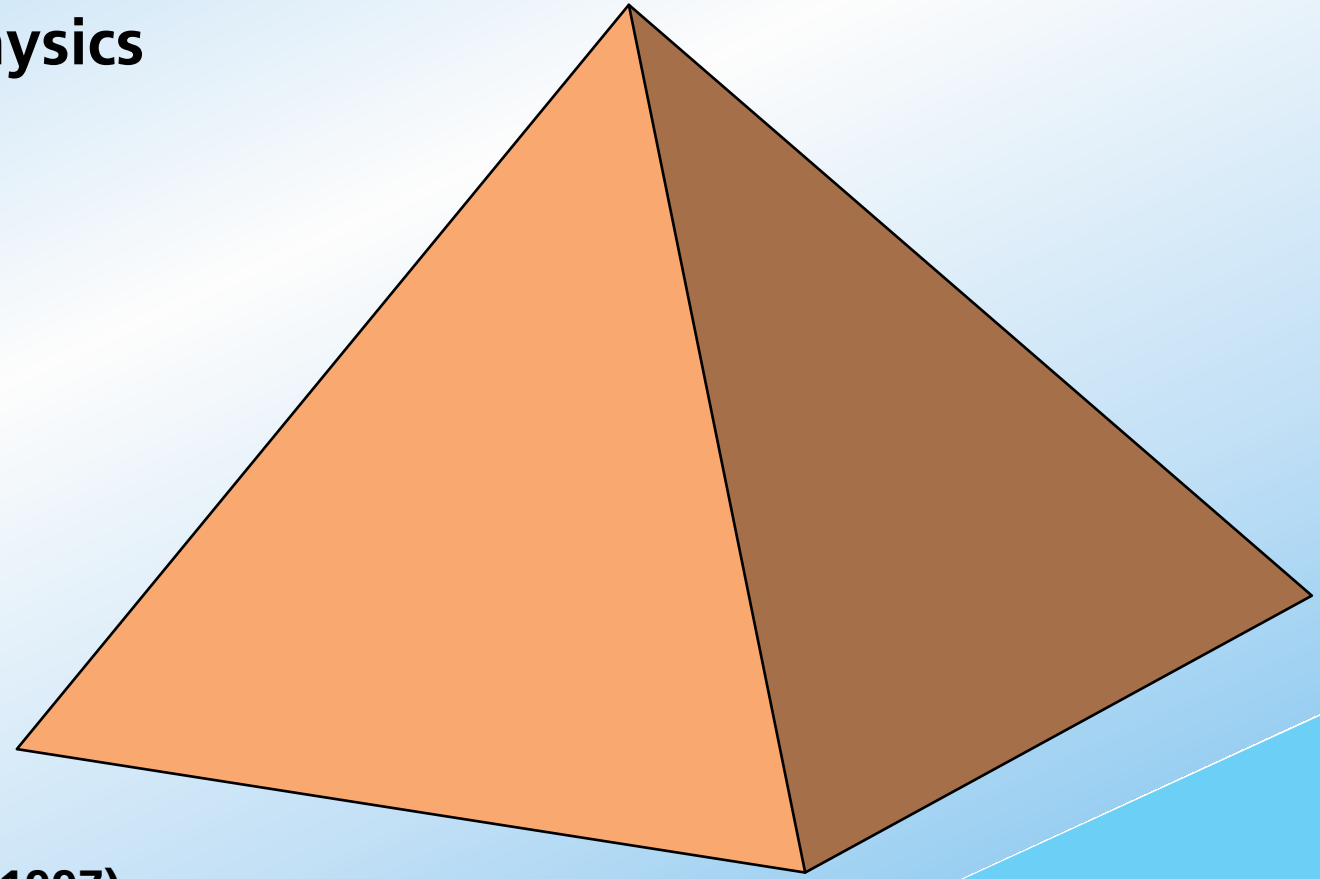
- **Problem**
- **Cause**

Outline

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

We have a problem

380,000 students take introductory physics each year…



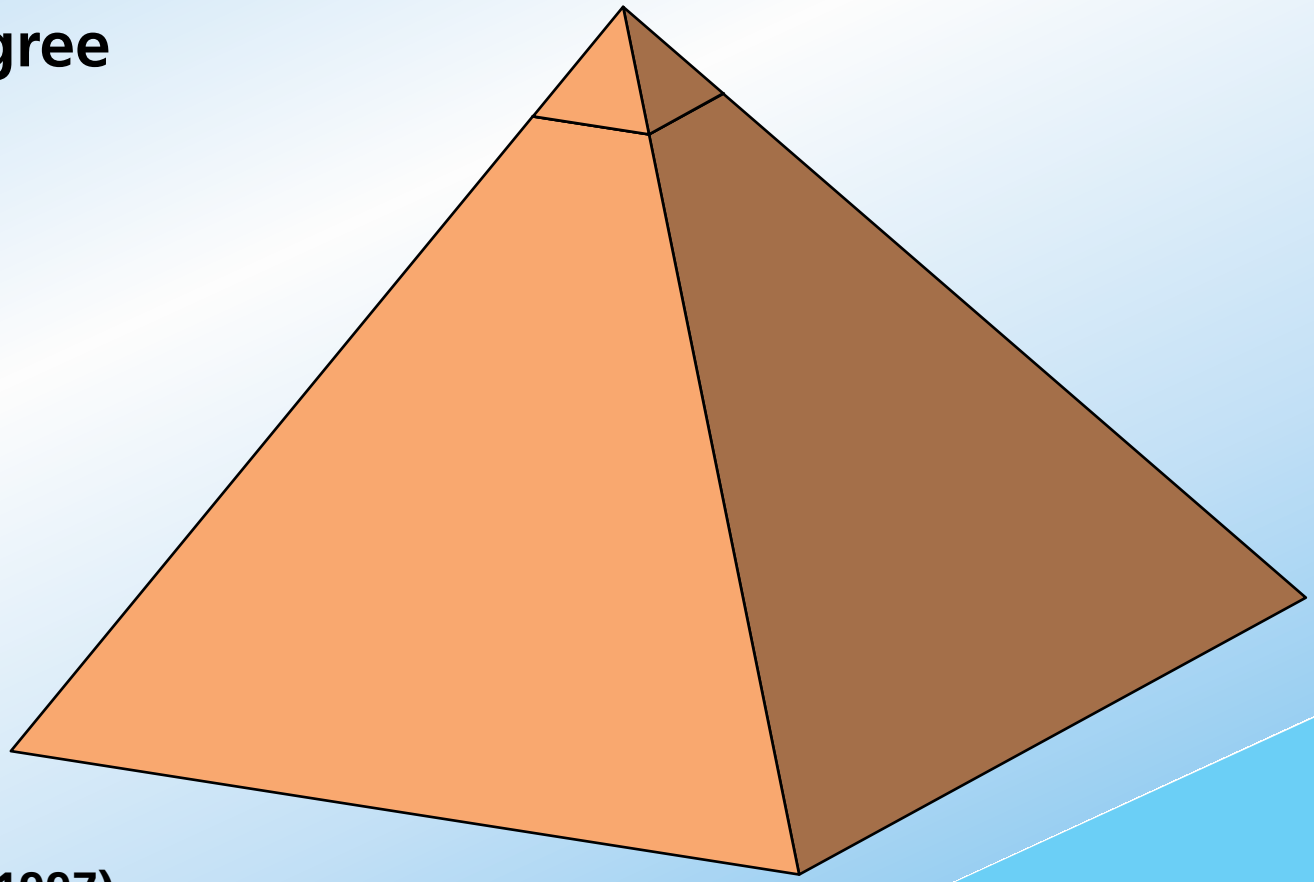
AIP Report R-151.33 **(1997)**

We have a problem

about 1% of these get

a bachelor's degree

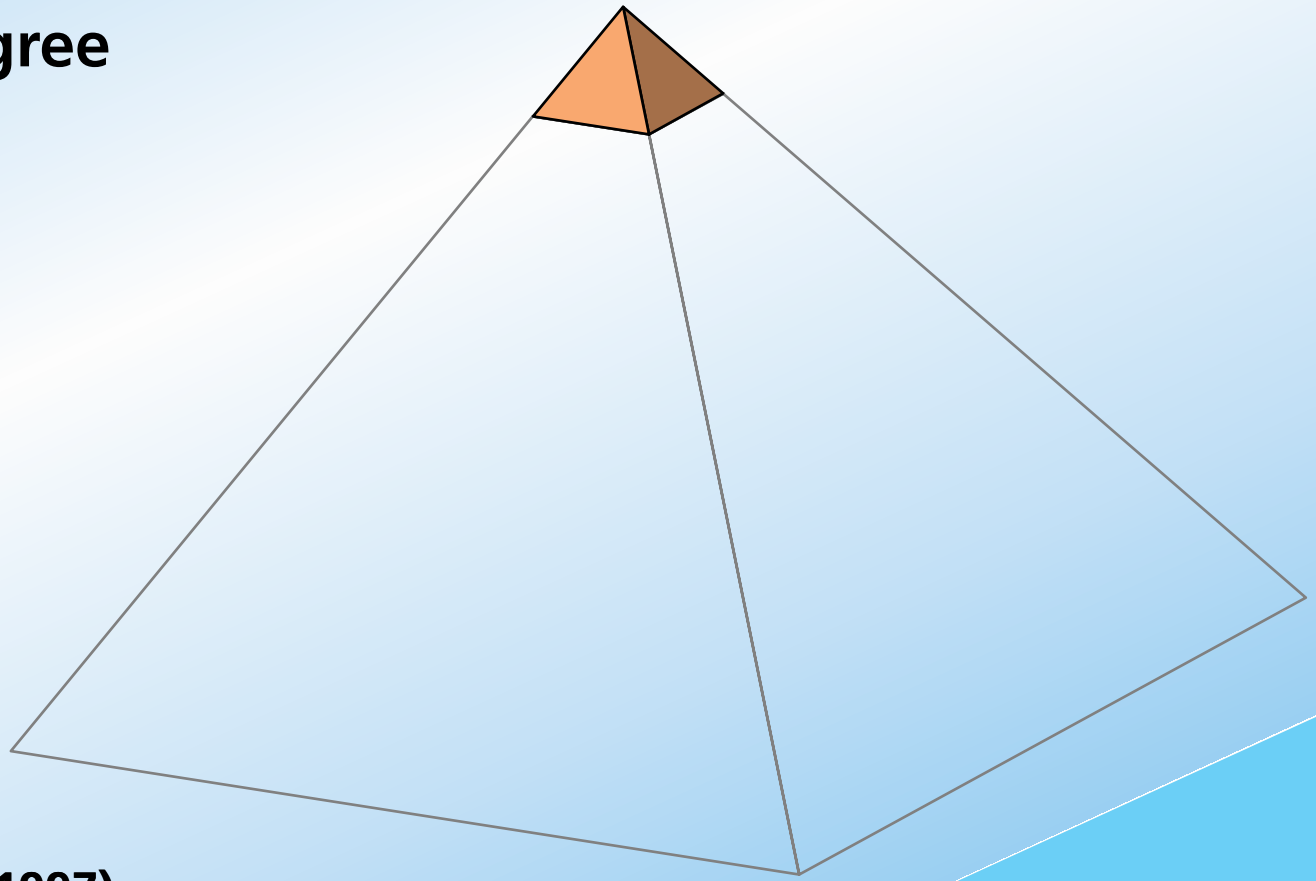
in physics



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

We have a problem

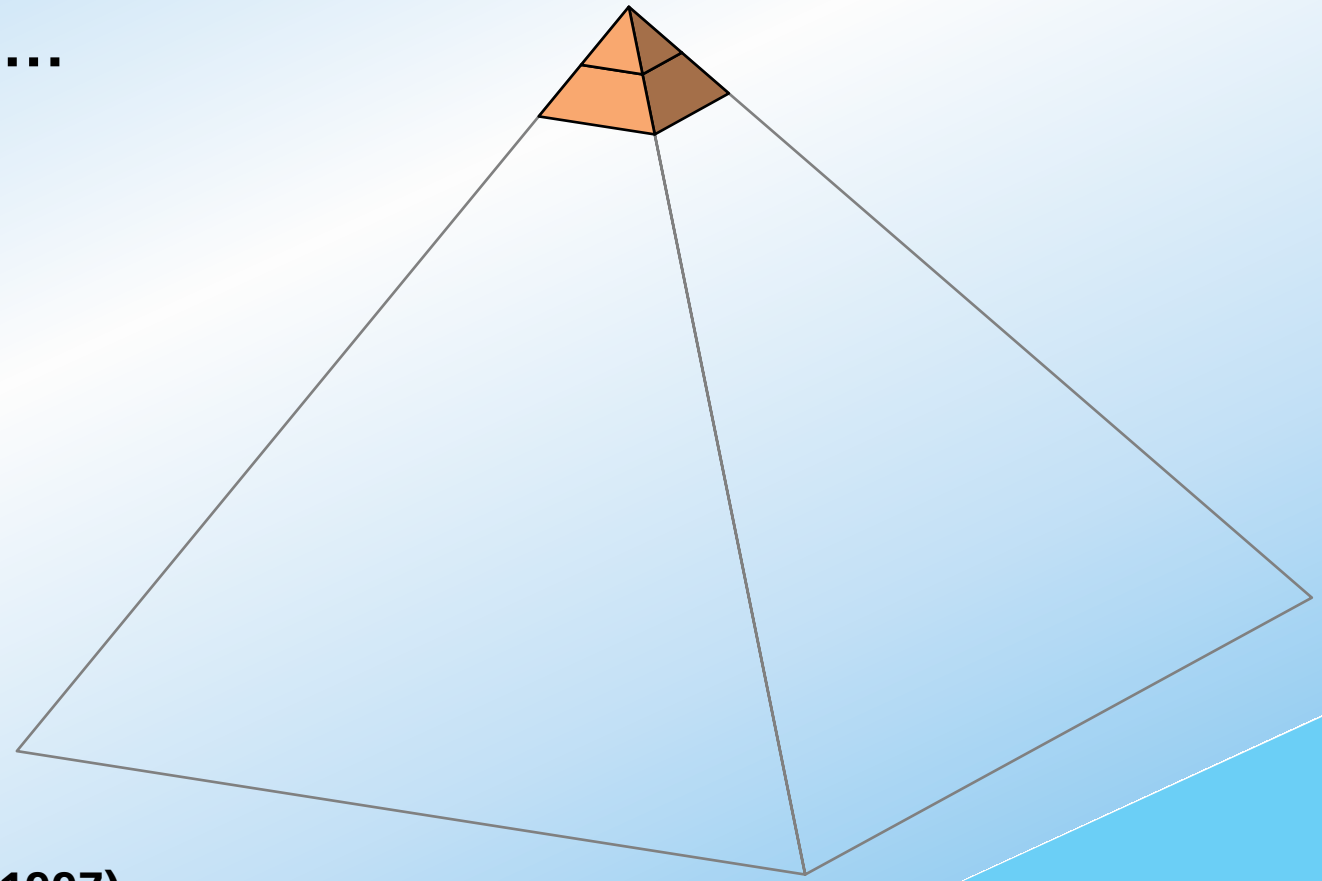
Of the 4,300 students with a bachelor's degree in physics…



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

We have a problem

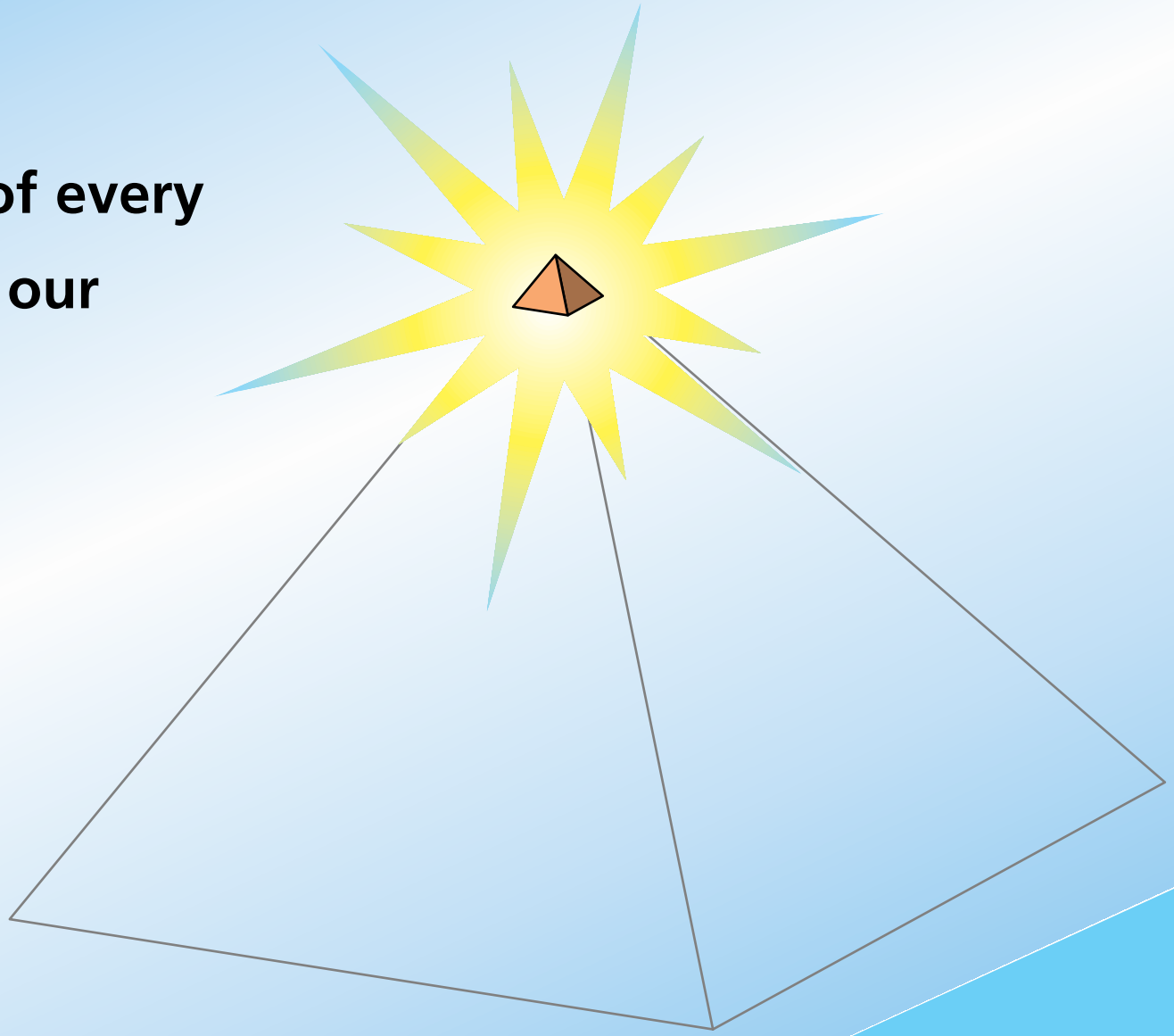
about 35% go on to get a Ph.D. in physics…



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

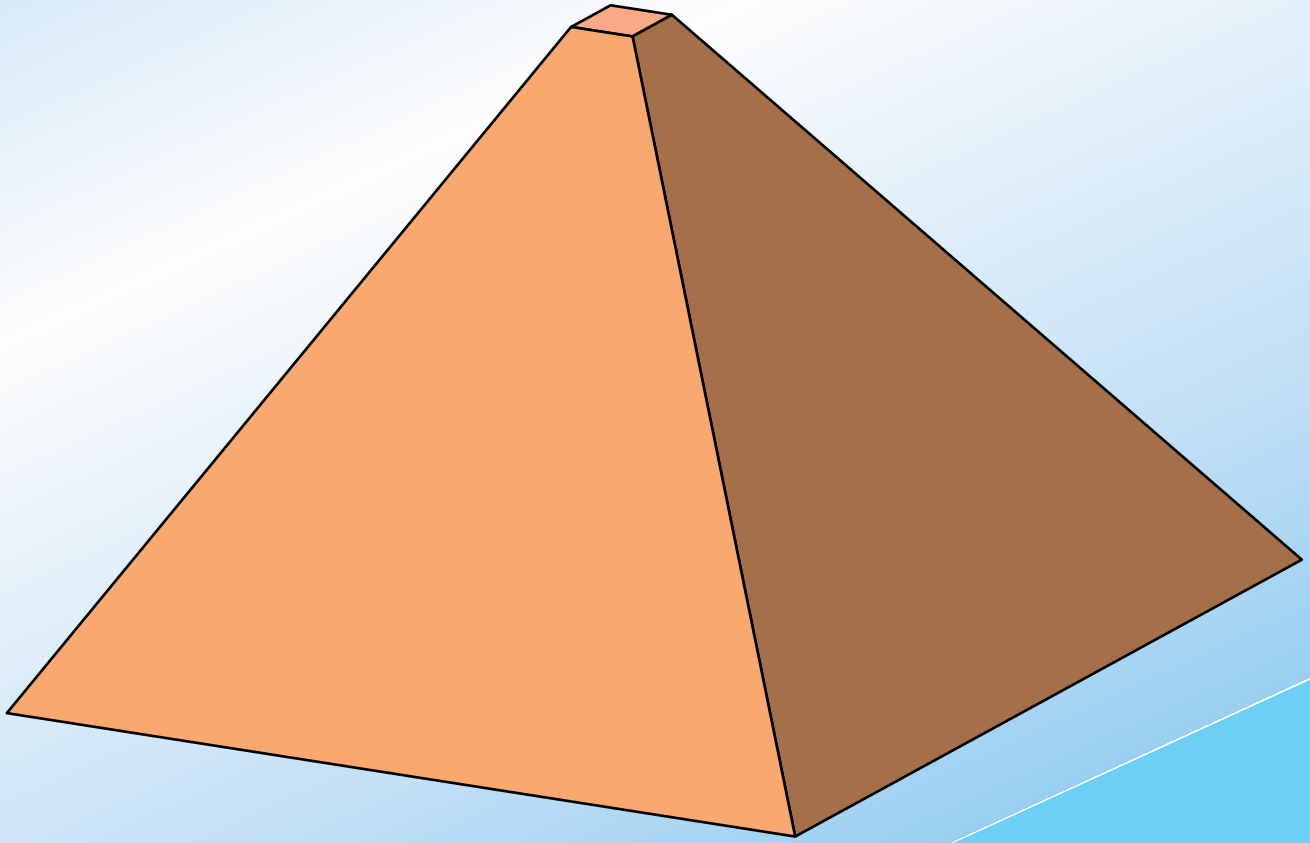
We have a problem

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



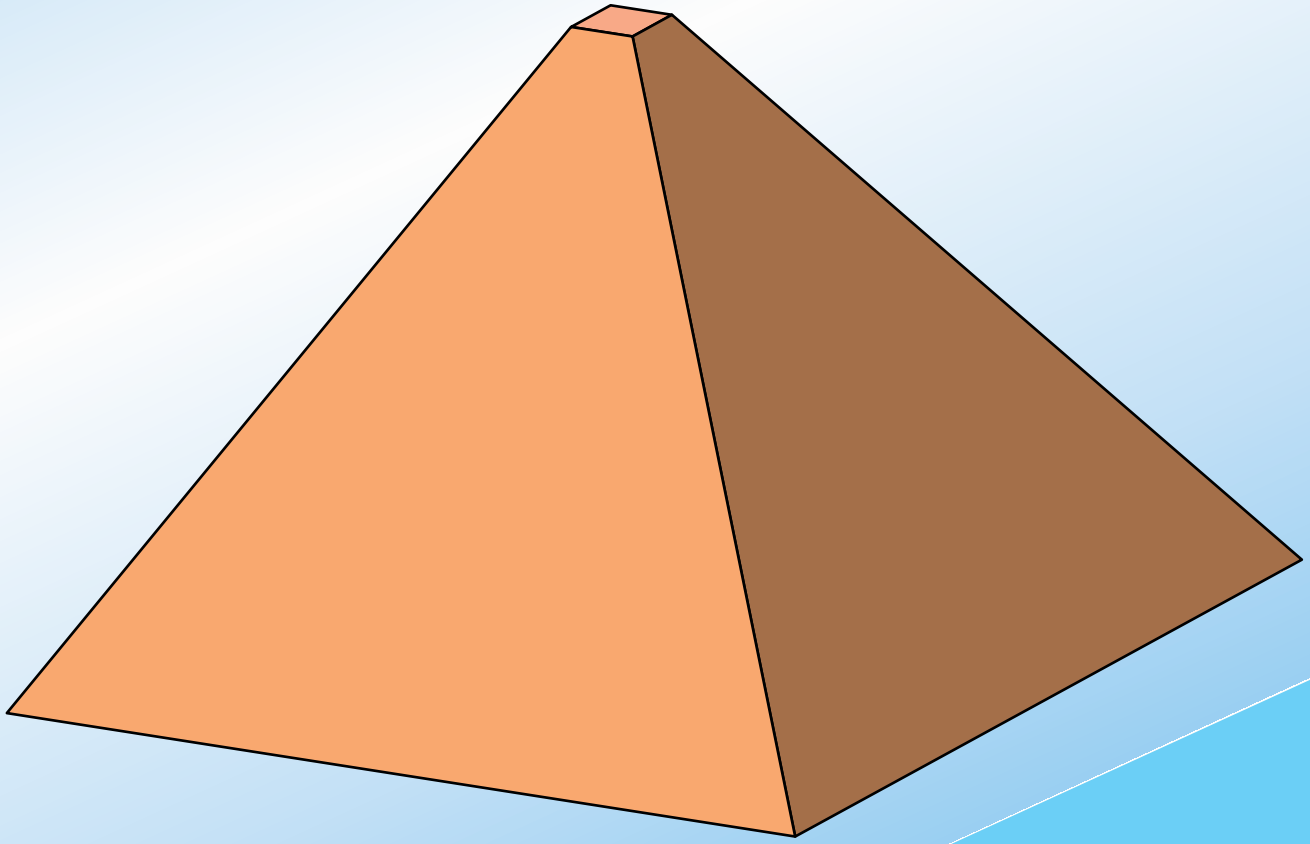
We have a problem

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*?"

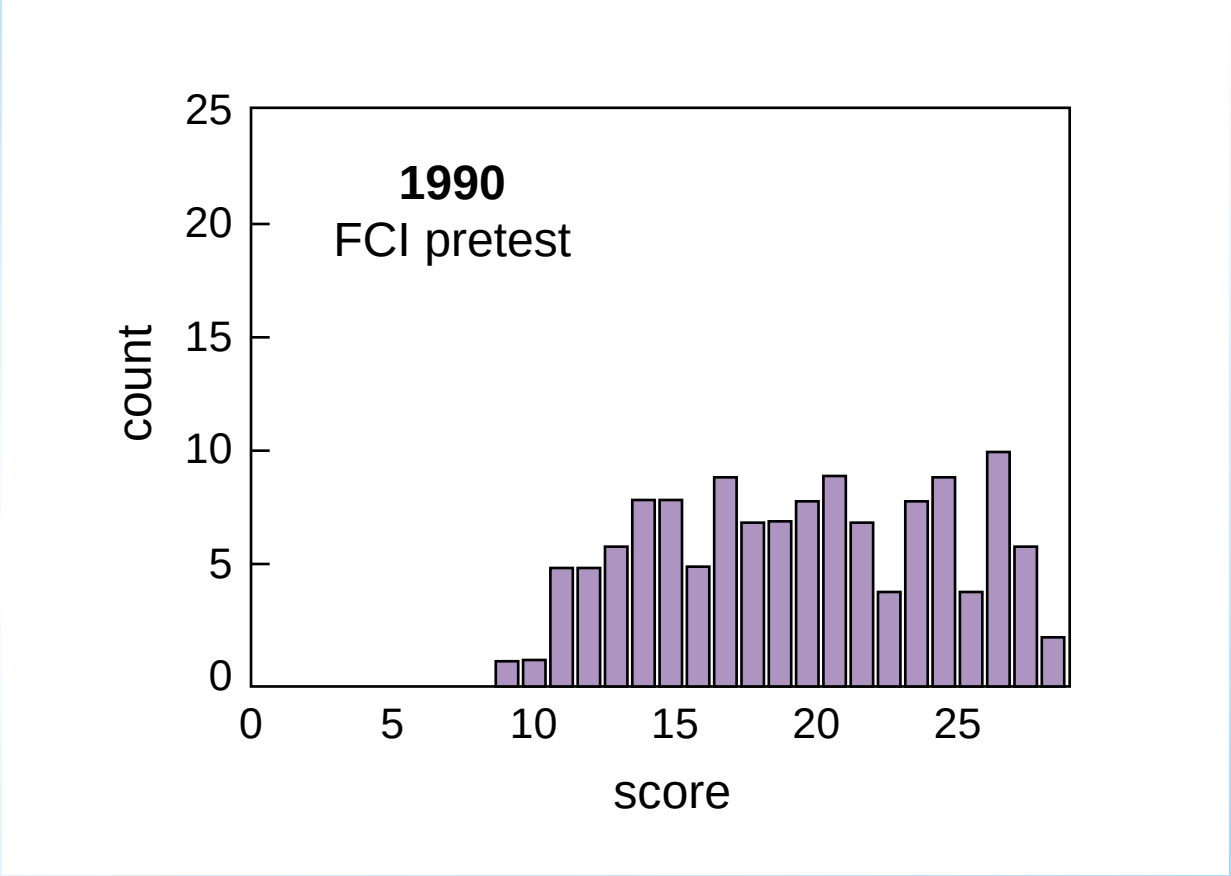

Why do we have this problem?

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)

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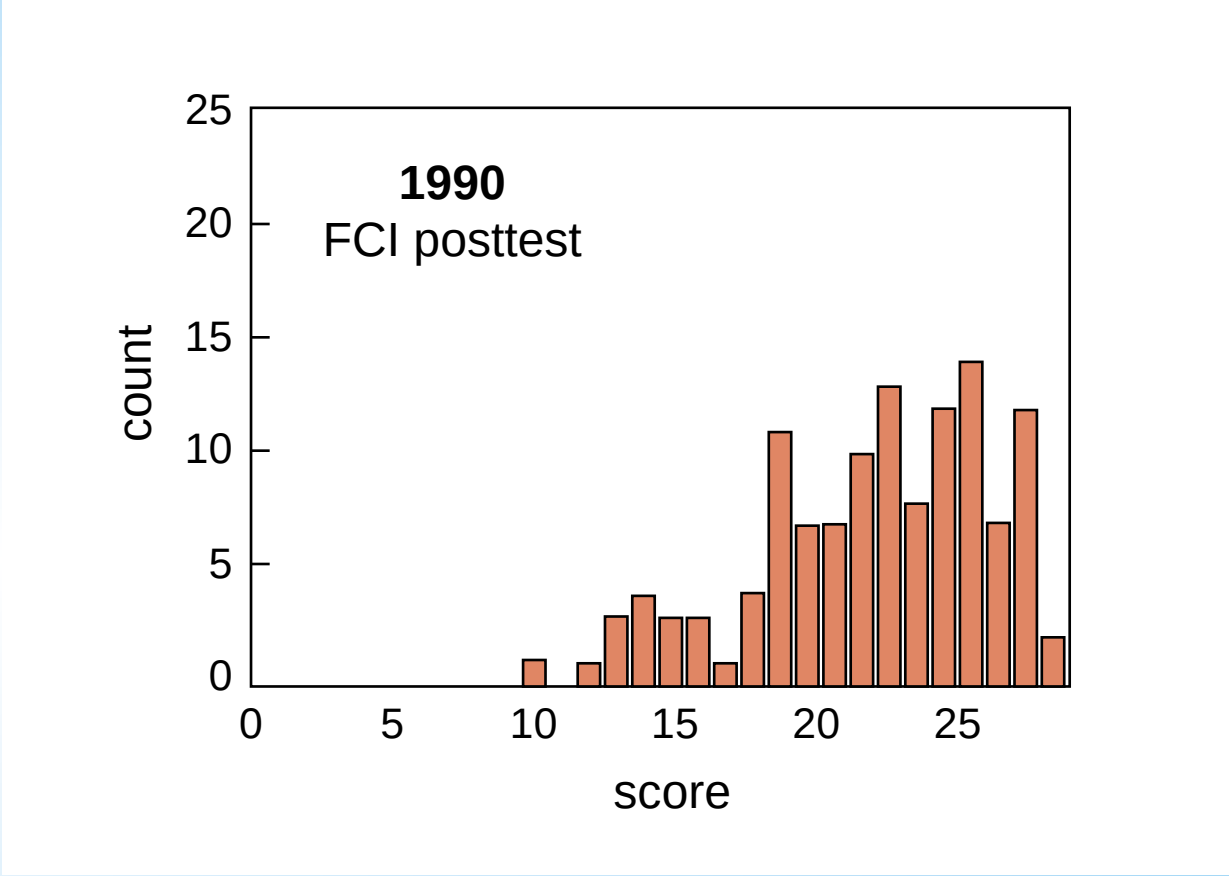

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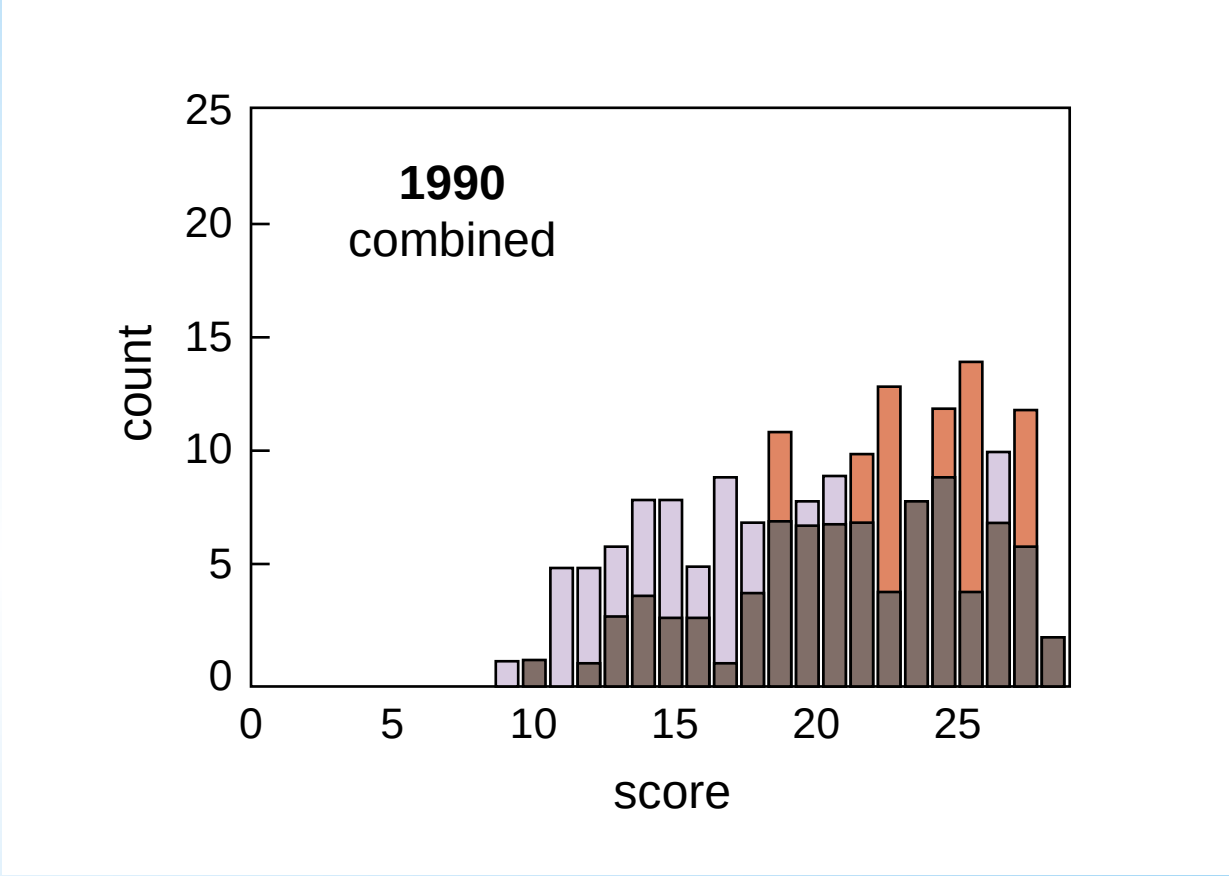

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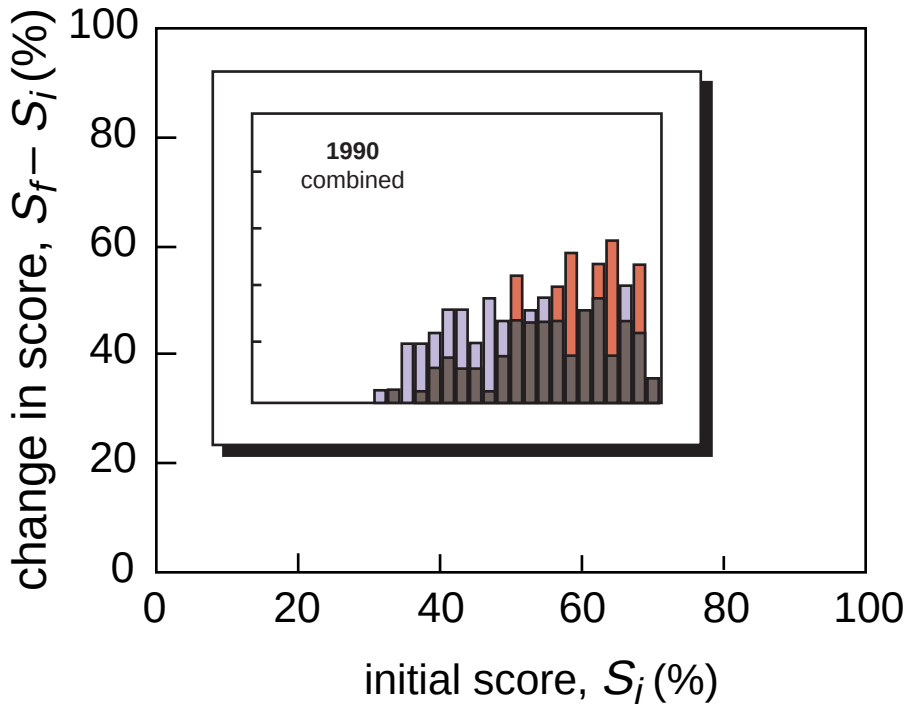

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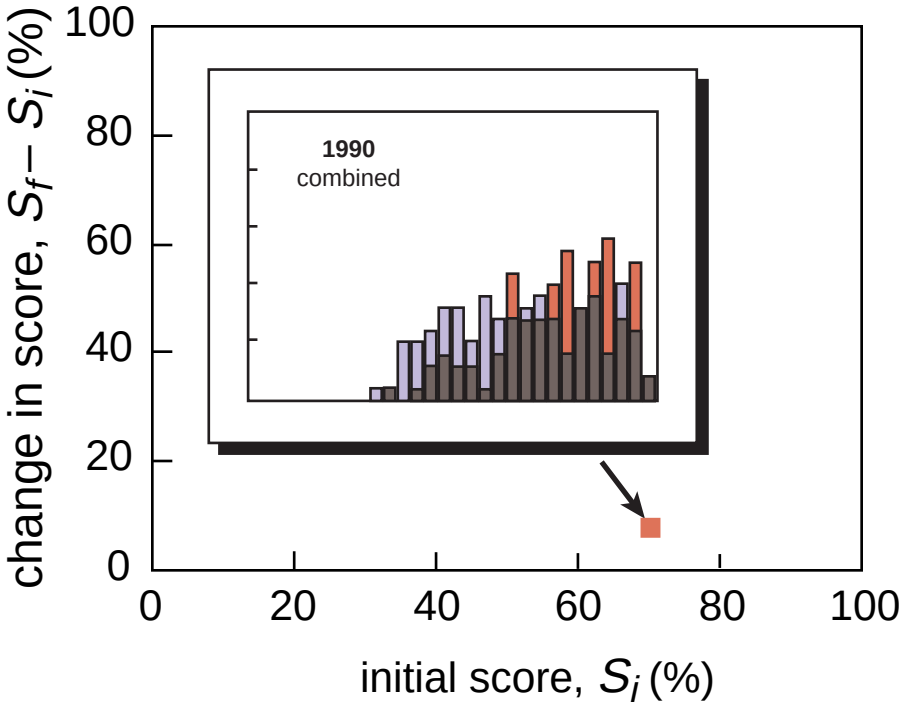

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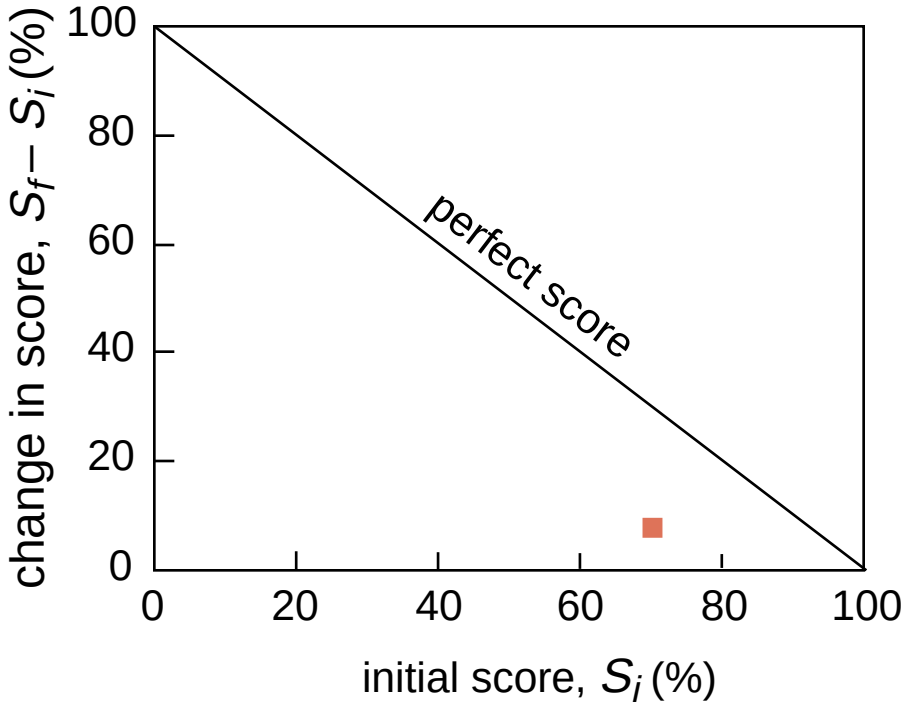

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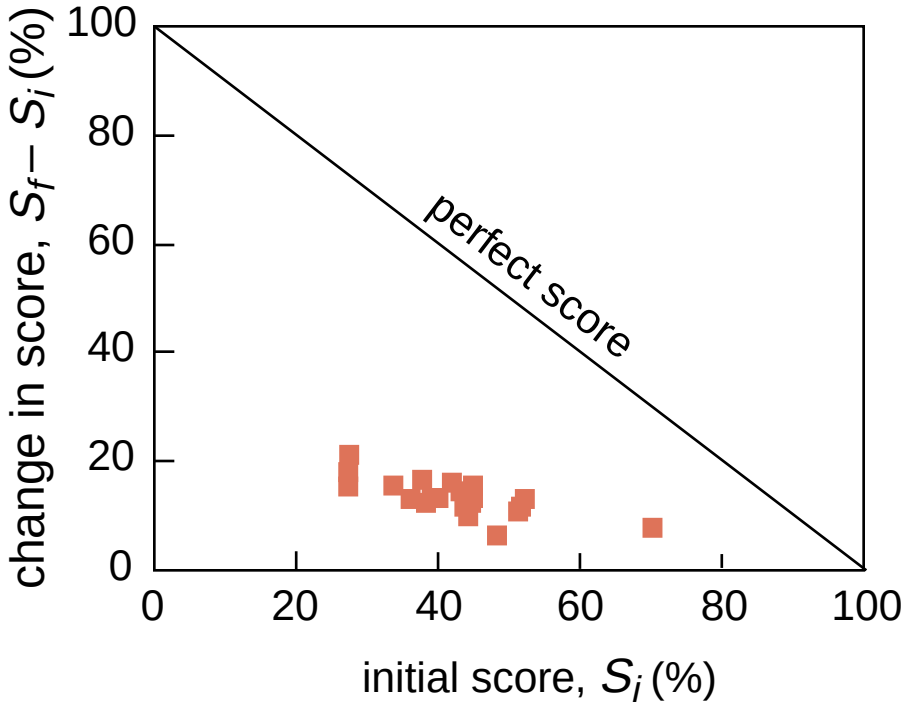

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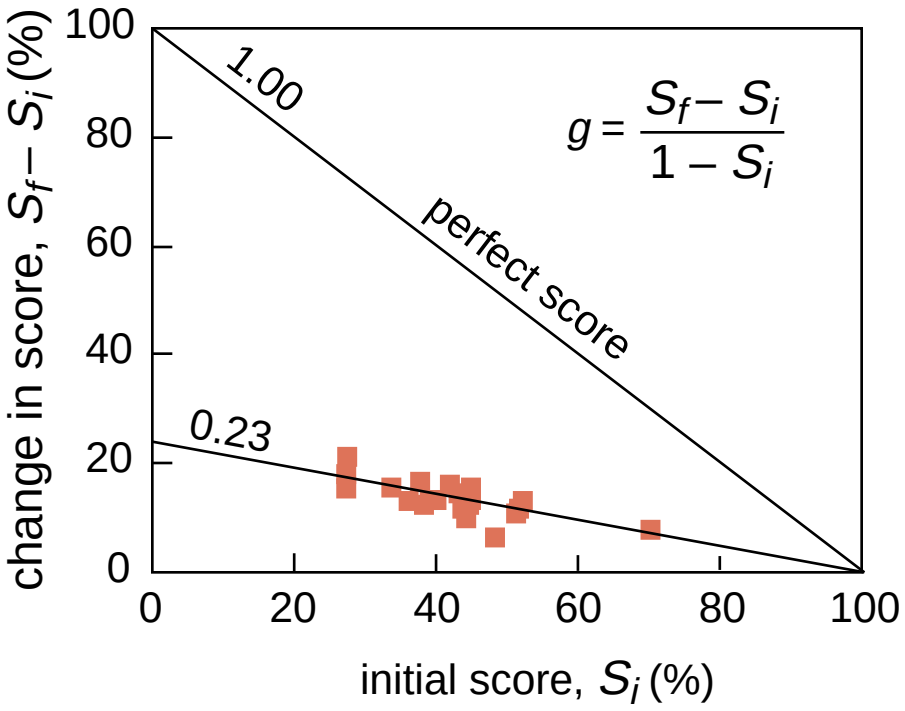

Why do we have this problem?

Conventional problems reinforce bad study habits

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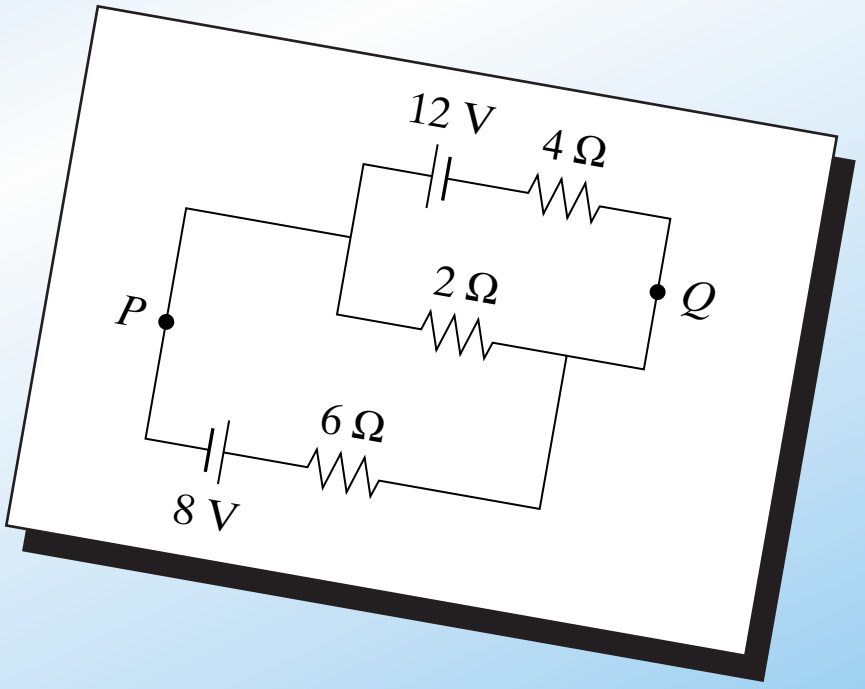


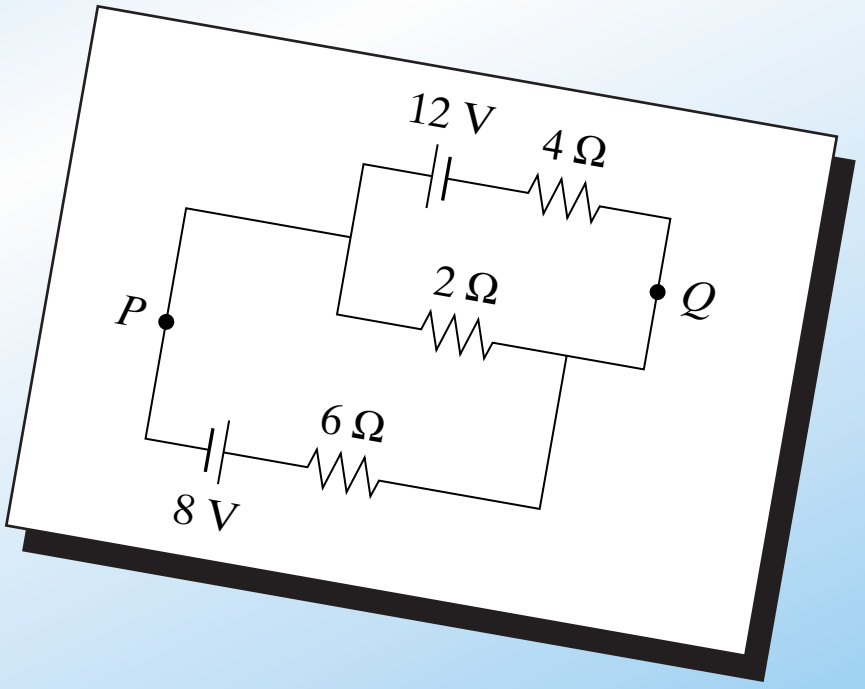
Why do we have this problem?

Conventional problems reinforce bad study habits

Calculate:

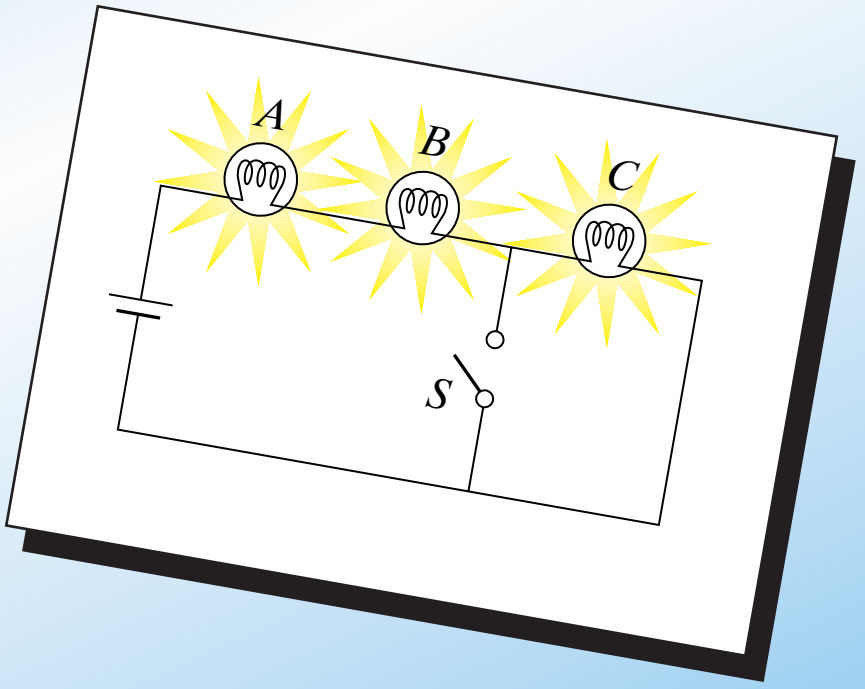
(*a*) the current in the 2-Ω resistor, and

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



Why do we have this problem?

Are basic principles understood?

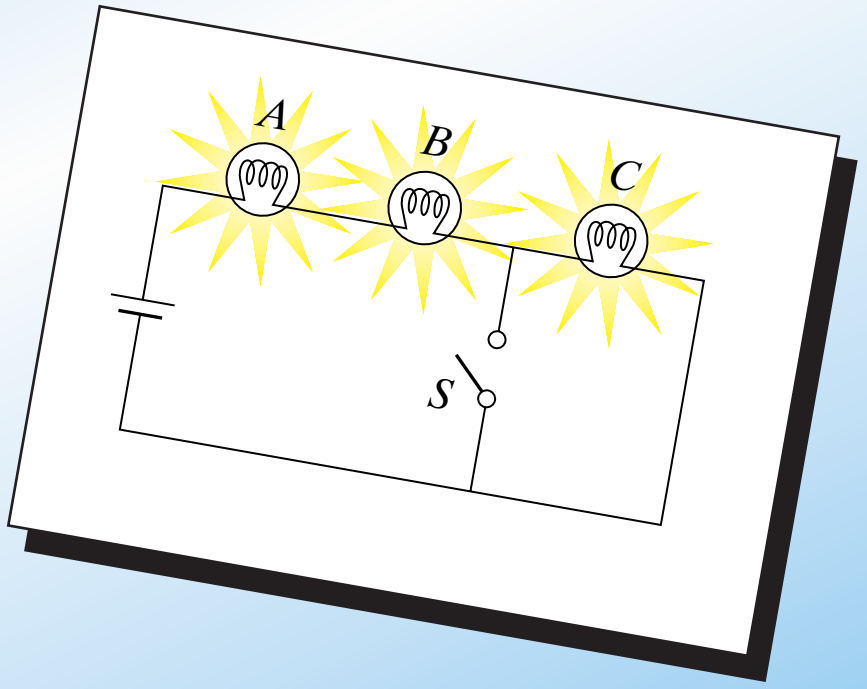


Why do we have this problem?

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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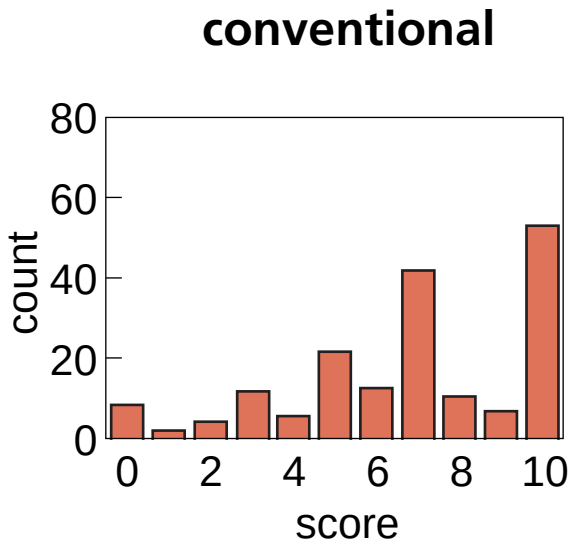

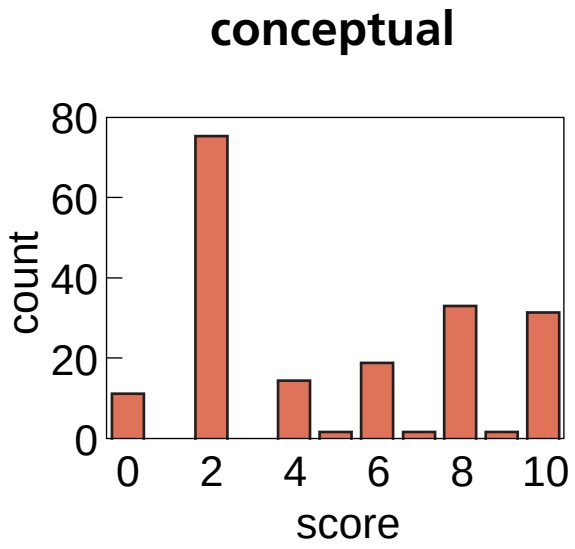

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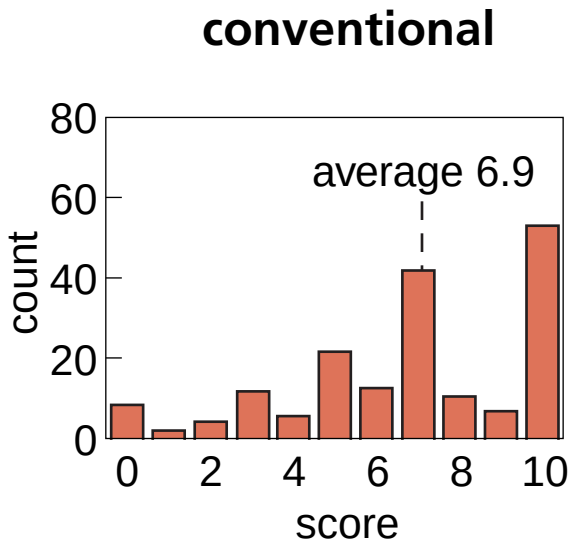

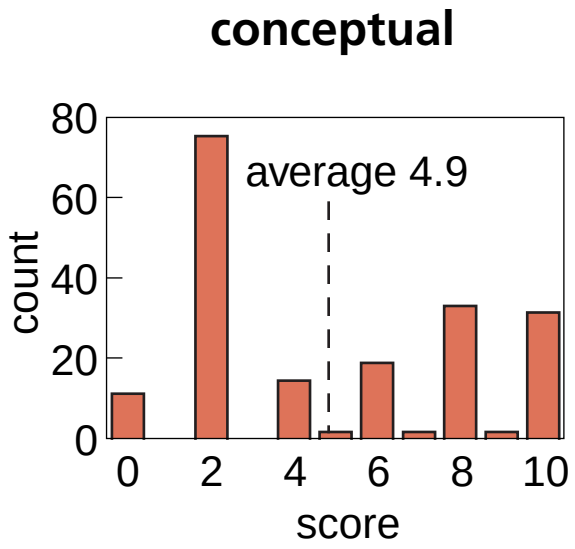

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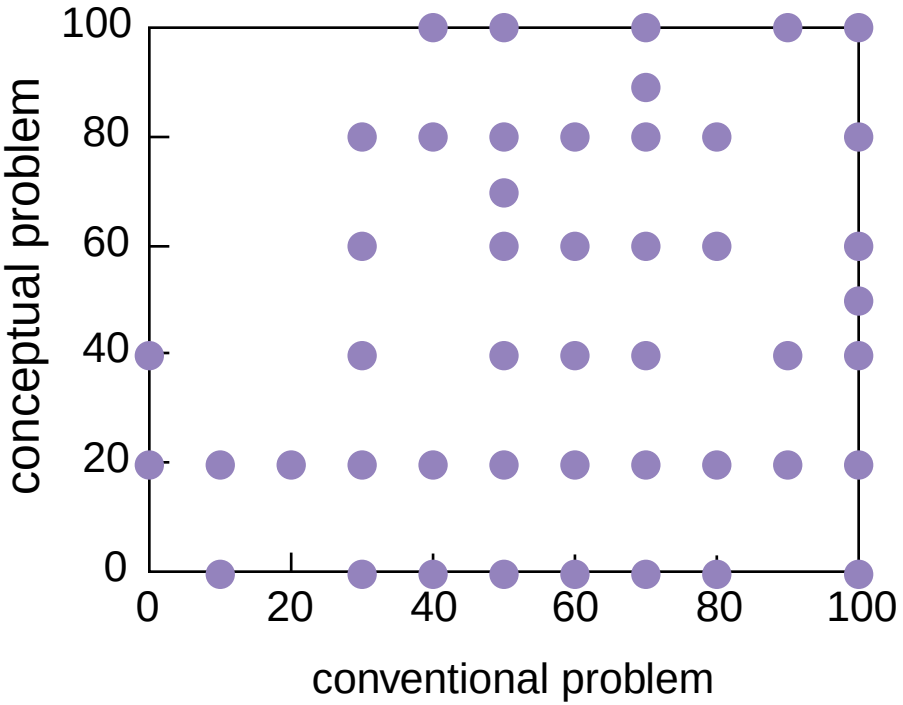

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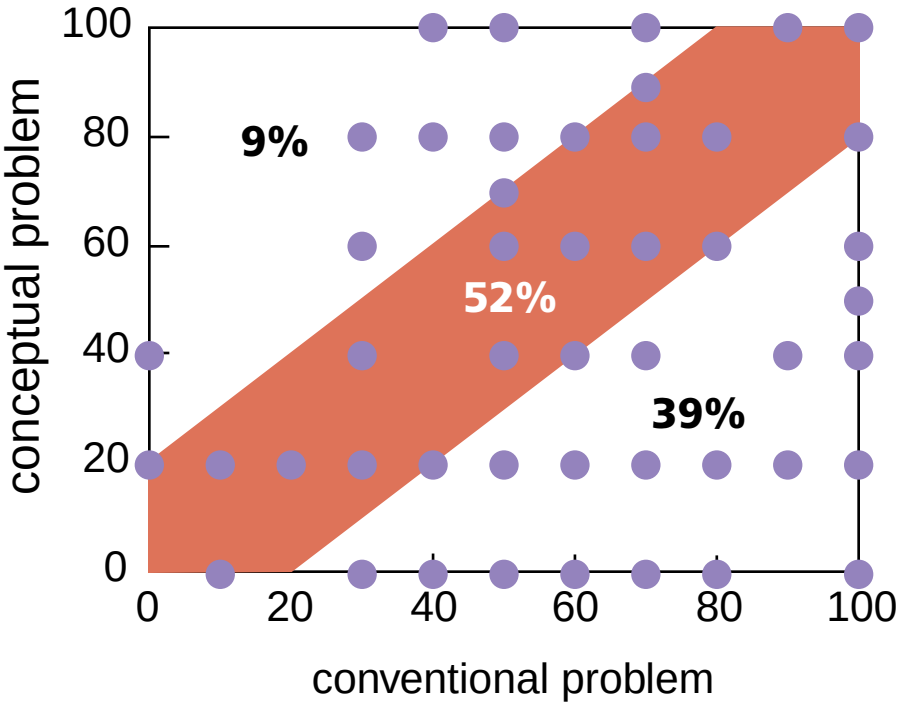



So what should we do?

Peer Instruction

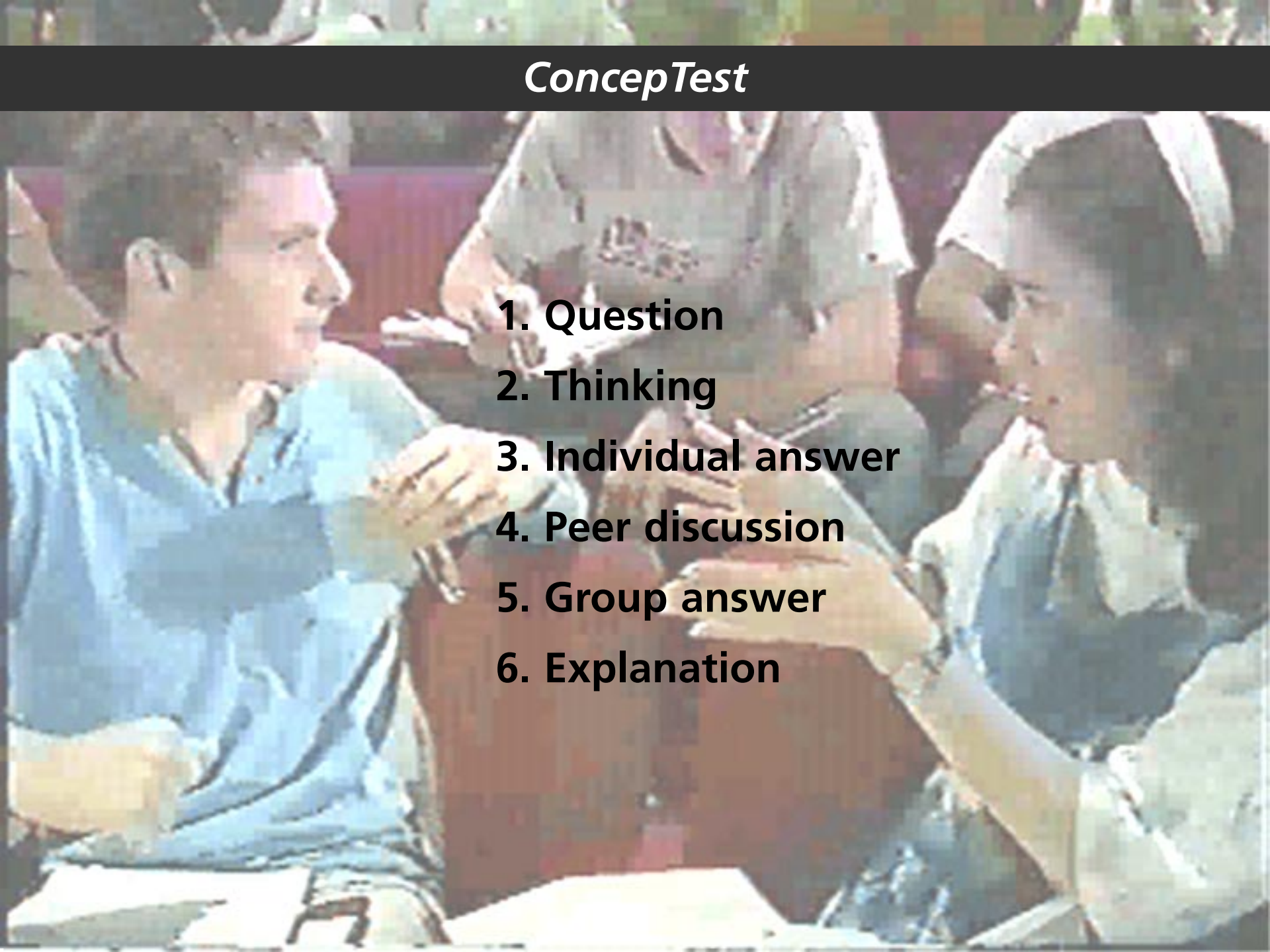
Help students take more responsibility for learning!

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?

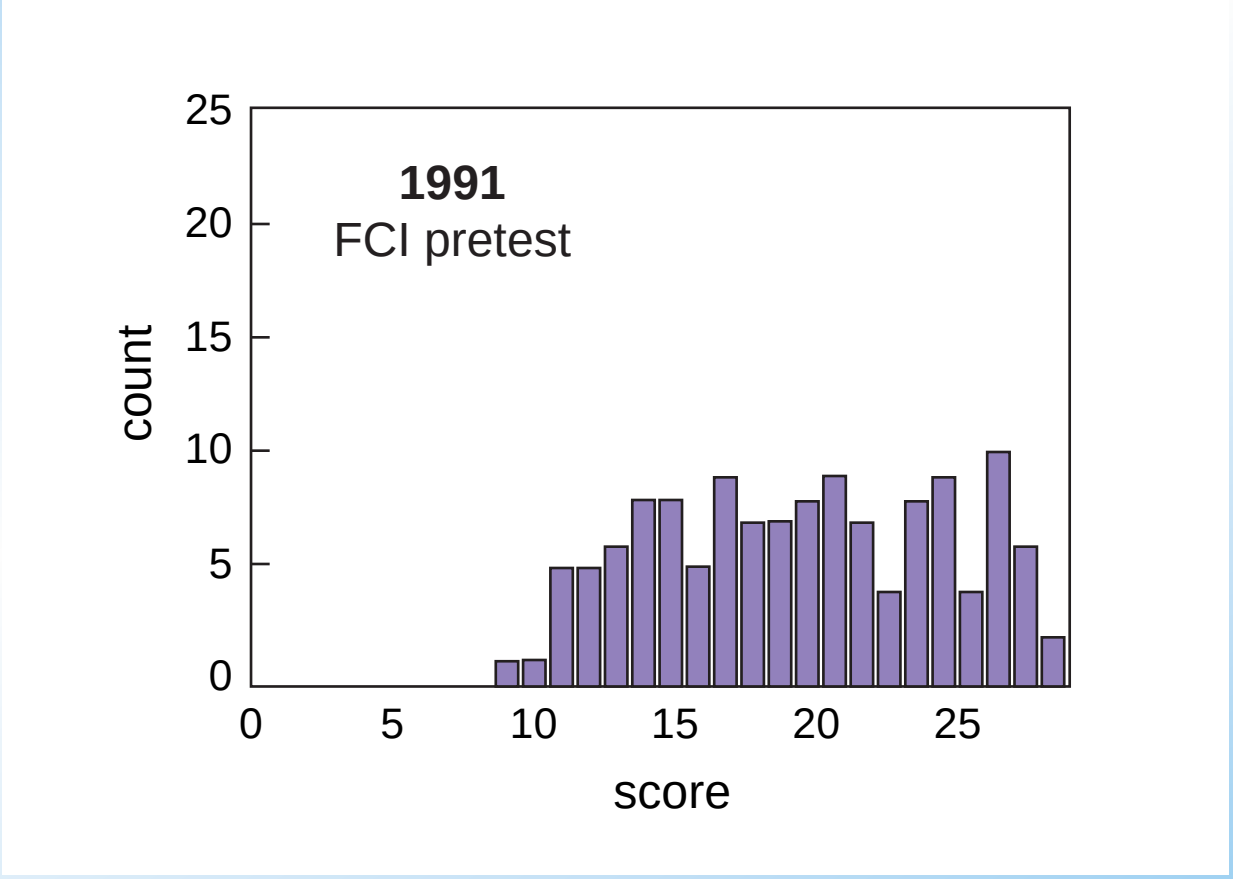
Is it any good?

- **Results**

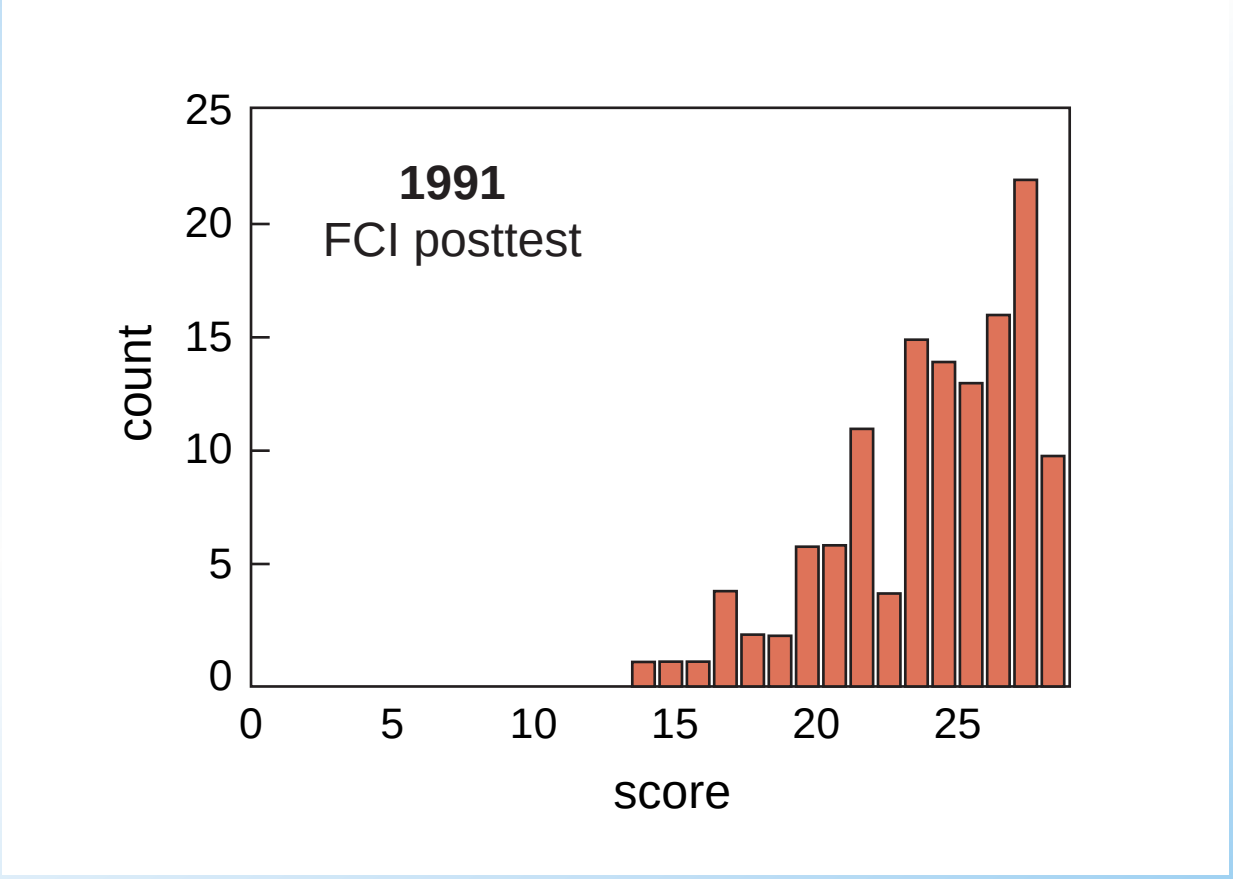
Is it any good?

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

Results



Results



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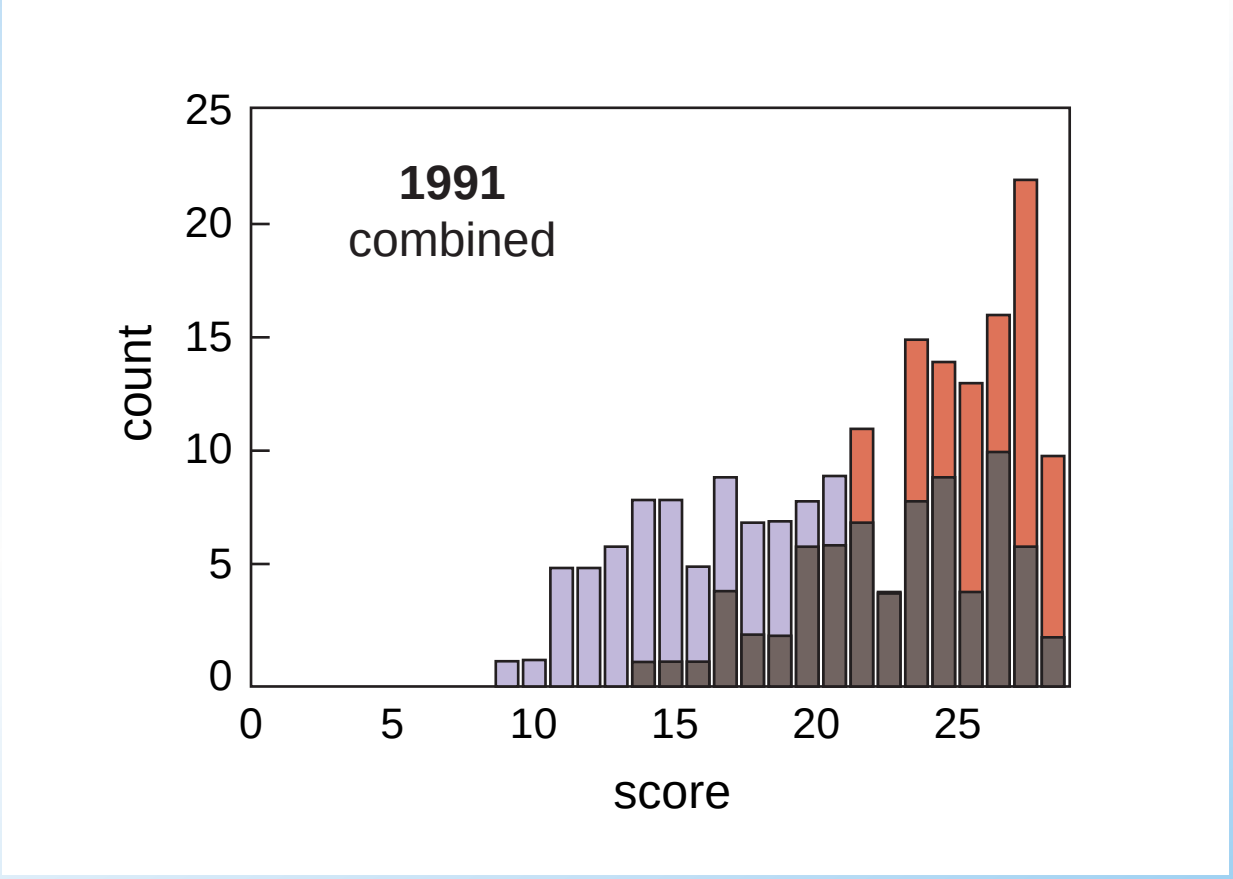

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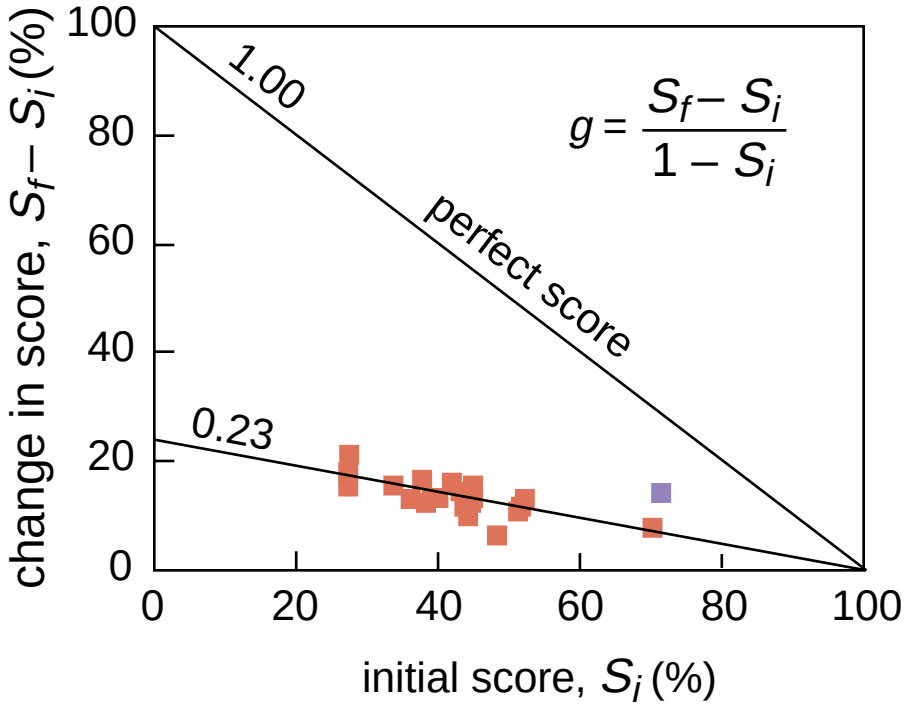
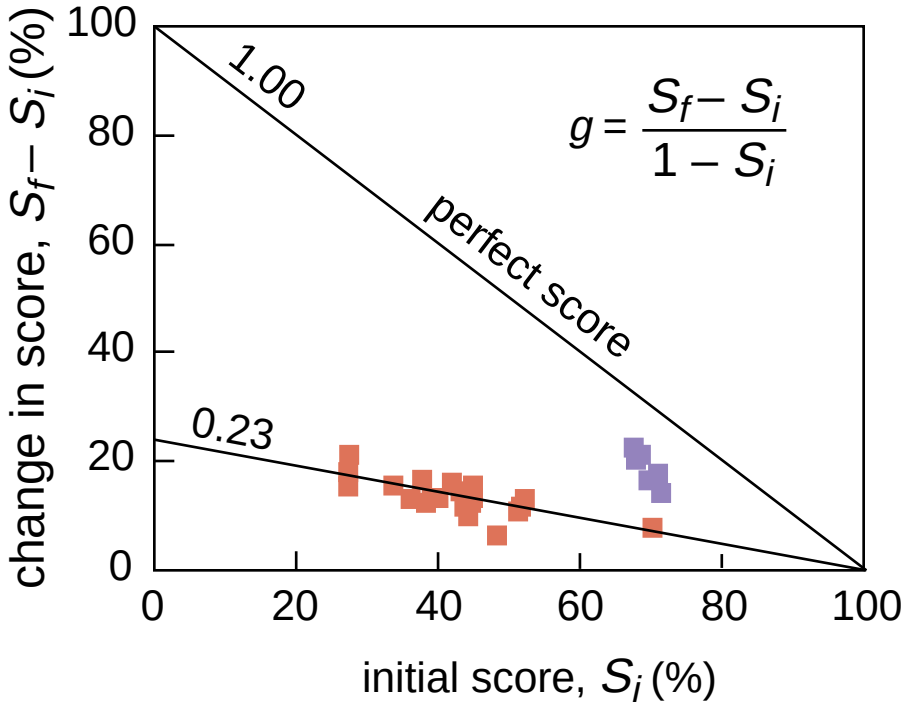

change in score, $S_f - S_i$ (%)
initial score, S_i (%)
0
20
40
60
80
100
1.00
perfect score
0.23
$g = \frac{S_f - S_i}{1 - S_i}$

Results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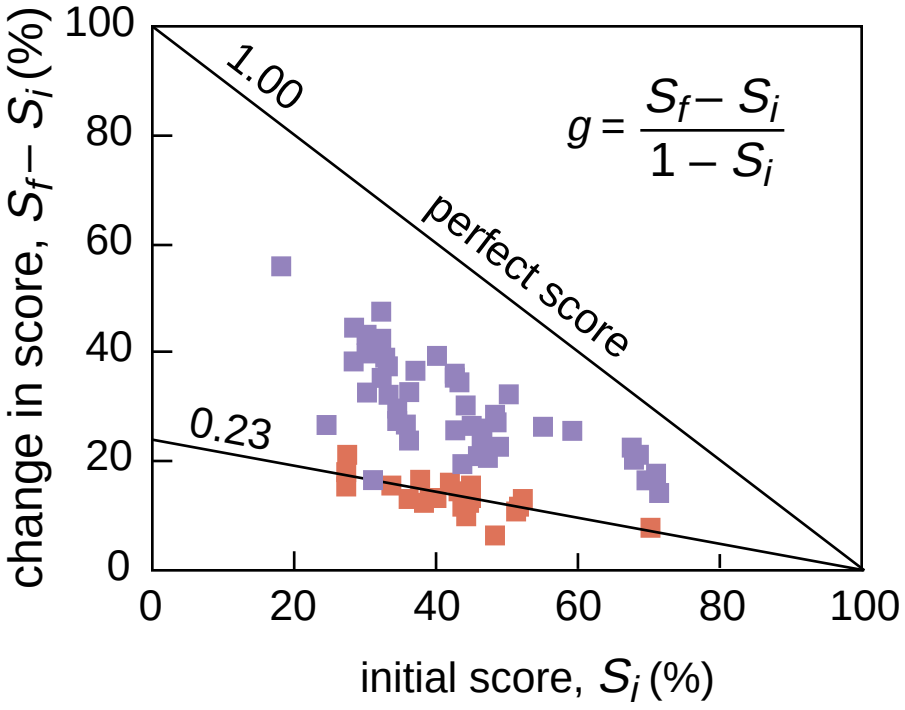
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1.00
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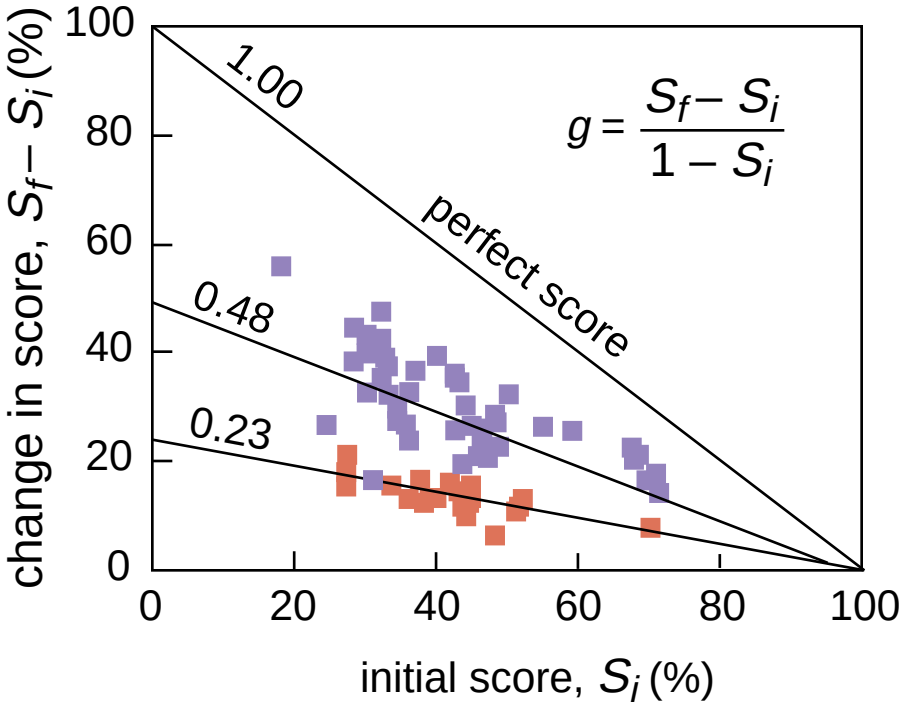
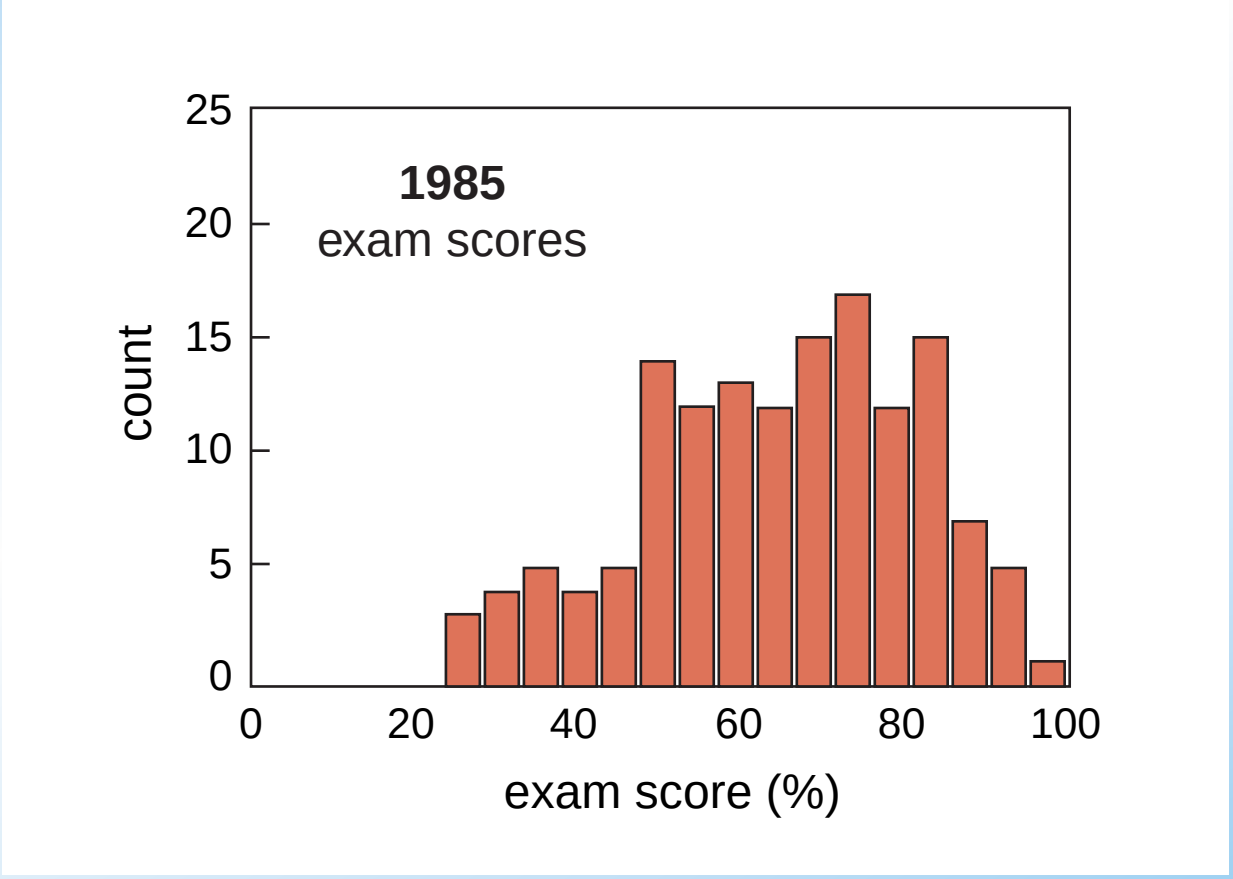

change in score, $S_f - S_i$ (%)
initial score, S_i (%)
0
20
40
60
80
100
1.00
perfect score
0.48
0.23
$g = \frac{S_f - S_i}{1 - S_i}$

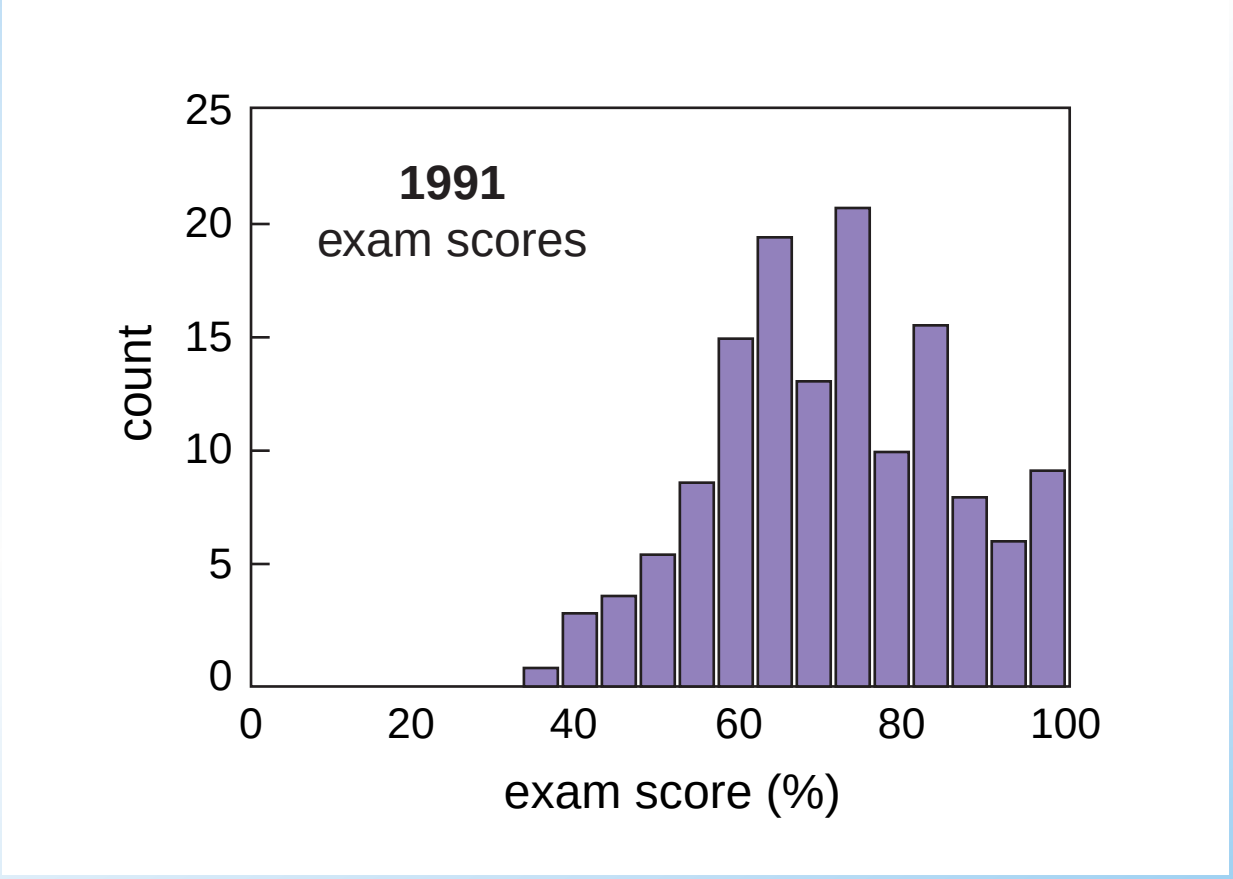
Results

What about problem solving…?

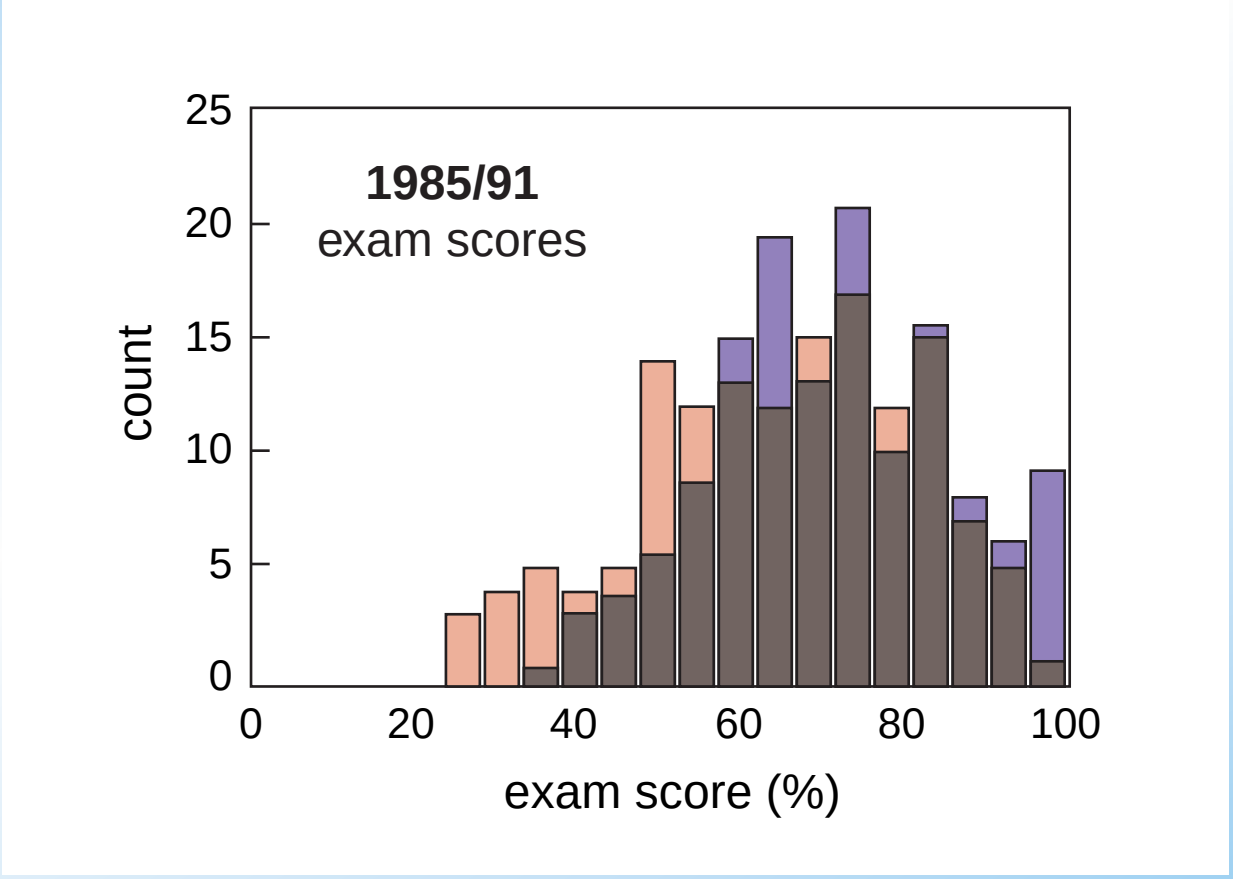
Results


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
60
80
100
exam score (%)

Results


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

Results

So better understanding leads to better problem solving!

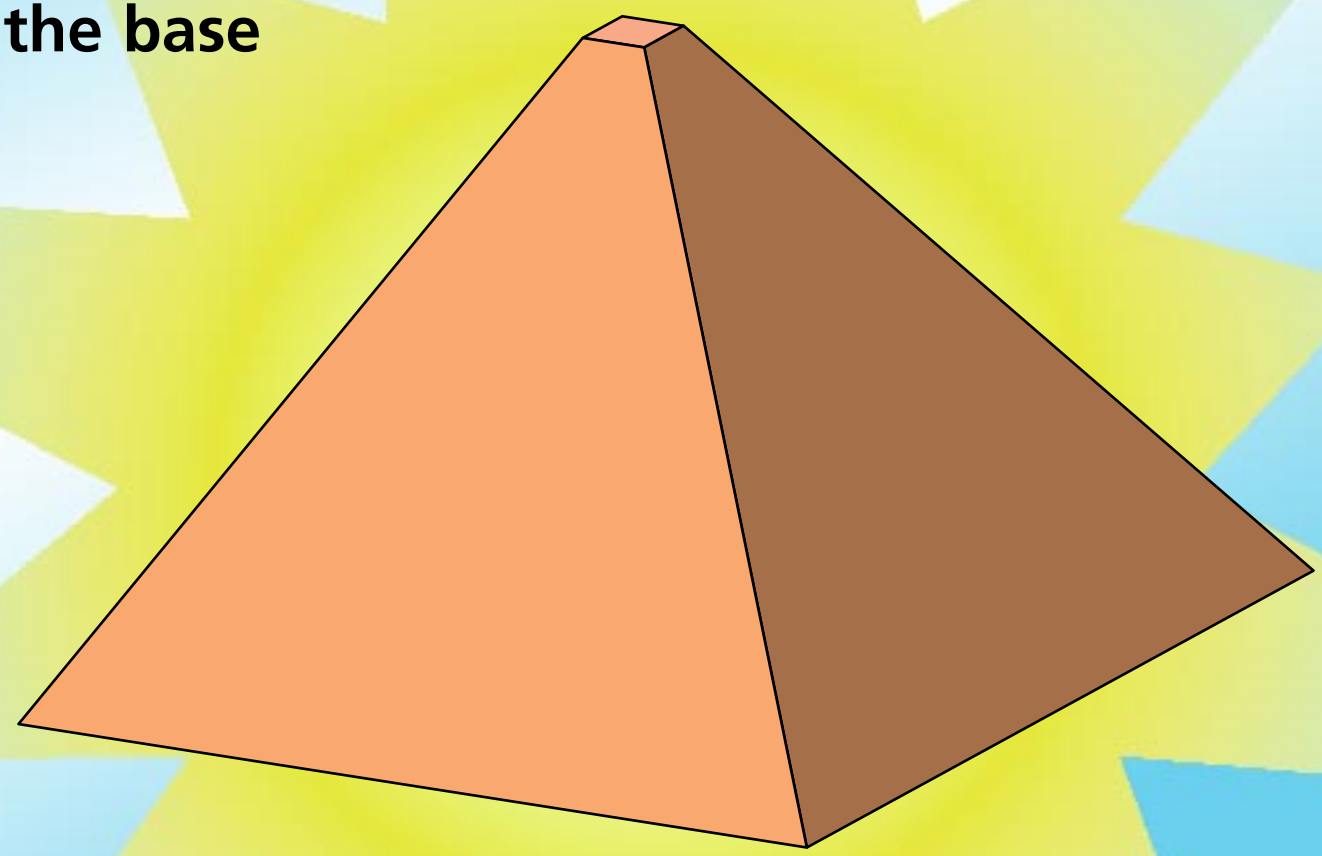
Results

So better understanding leads to better problem solving!

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

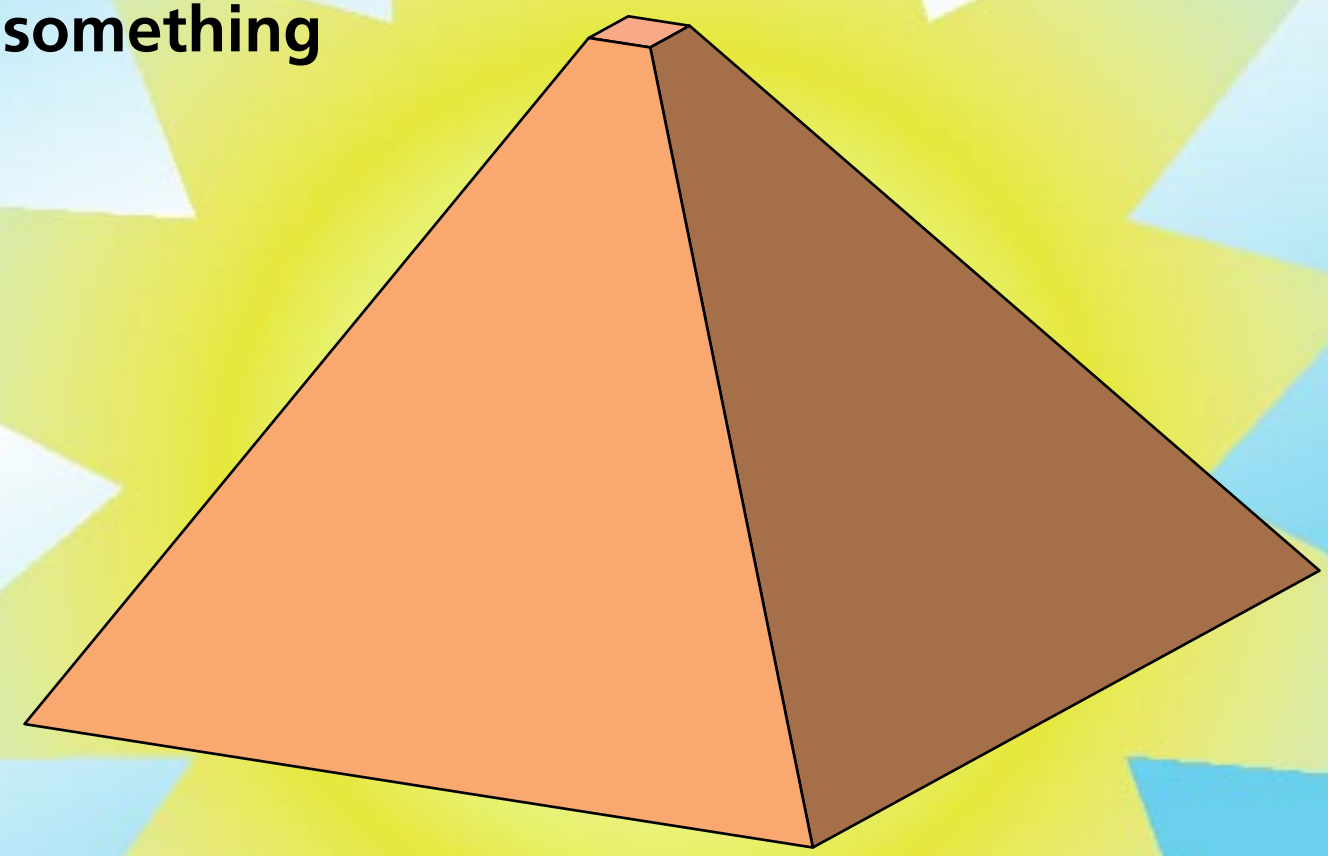
Conclusion

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