

UNDERSTANDING OR MEMORIZATION: ARE WE TEACHING THE RIGHT THING?

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Outline

▶ **Problem**

Outline

▶ **Problem**

▶ **Cause**

Outline

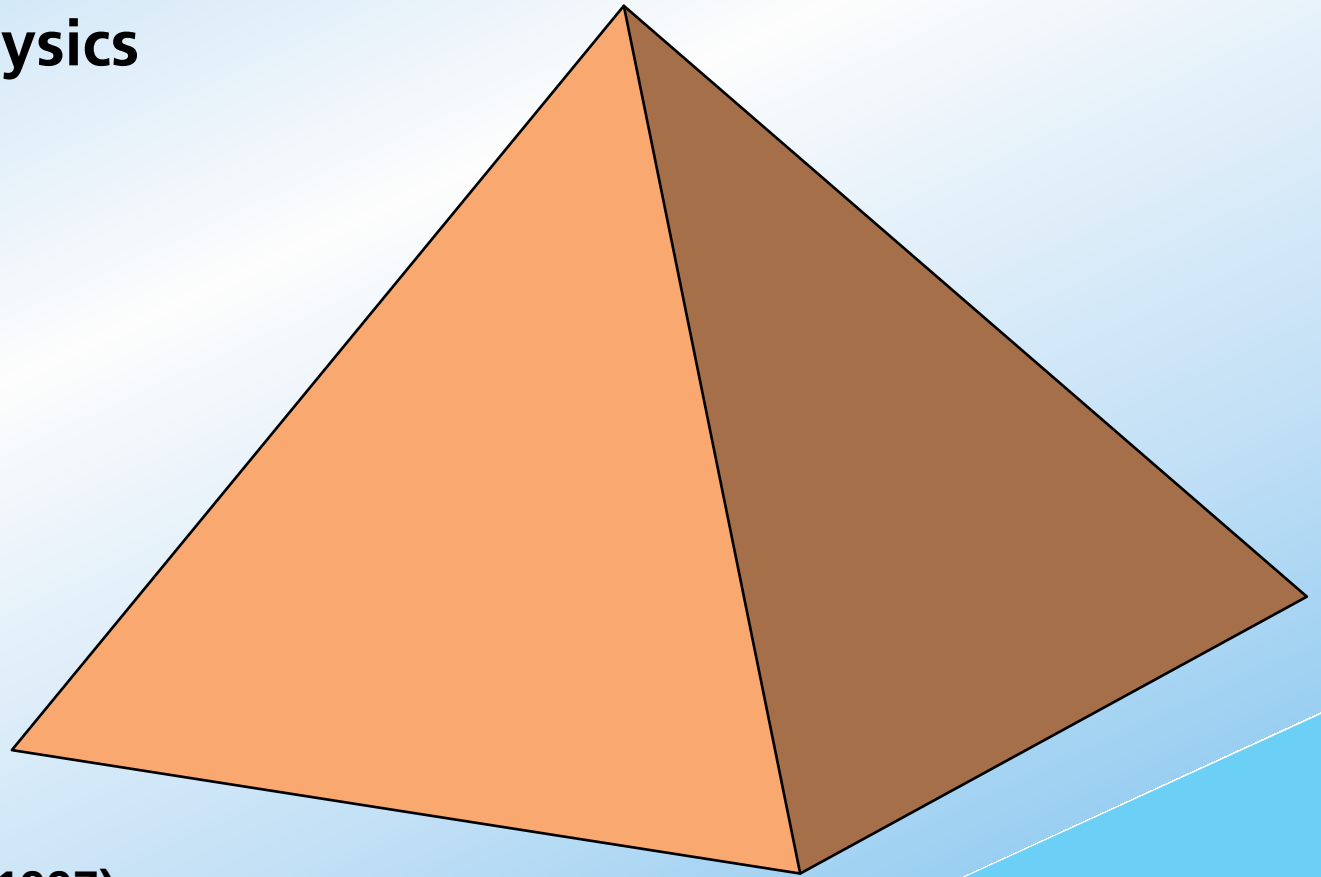
▶ **Problem**

▶ **Cause**

▶ **Remedy**

We have a problem

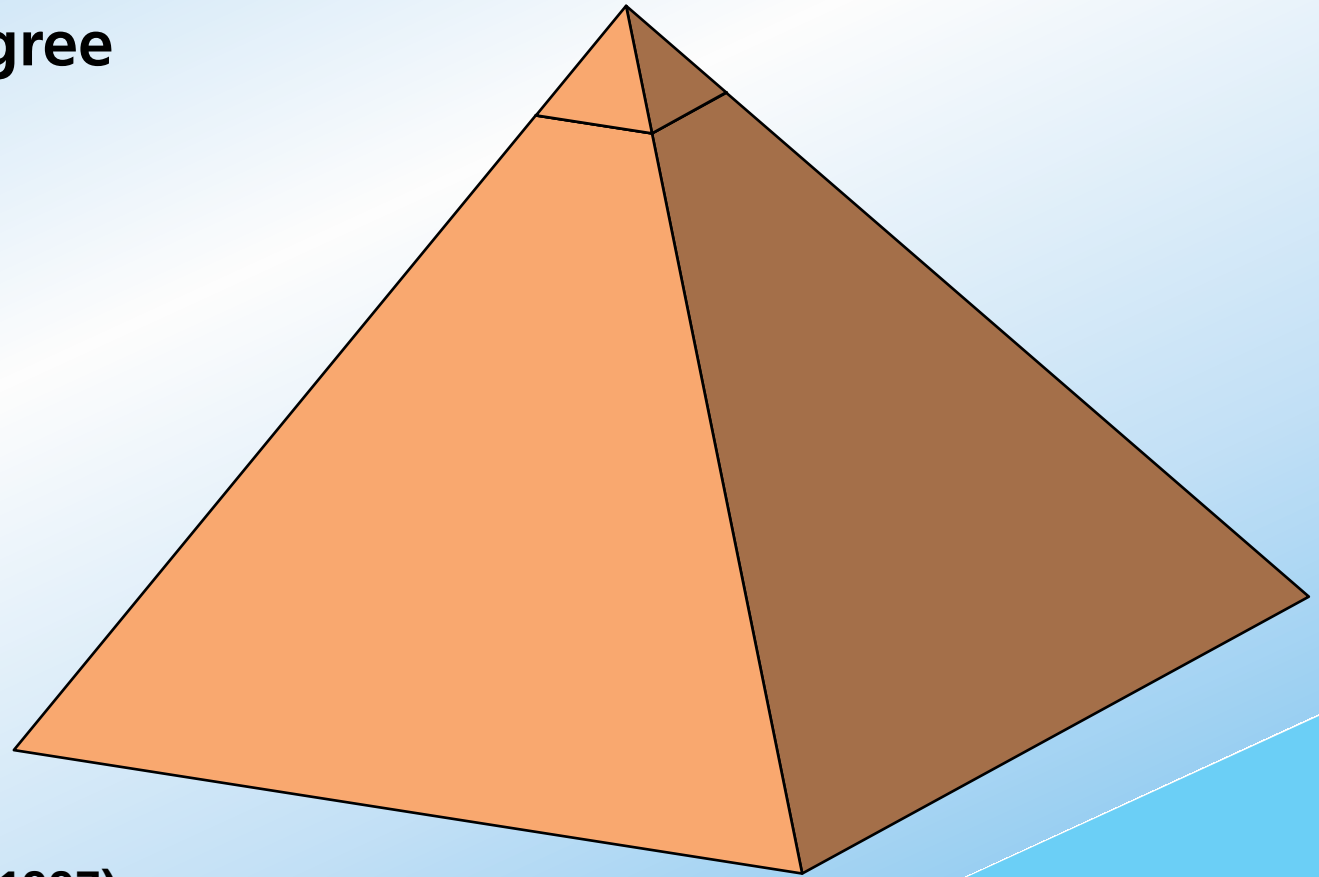
**380,000 students take
introductory physics
each year...**



AIP Report R-151.33 (1997)

We have a problem

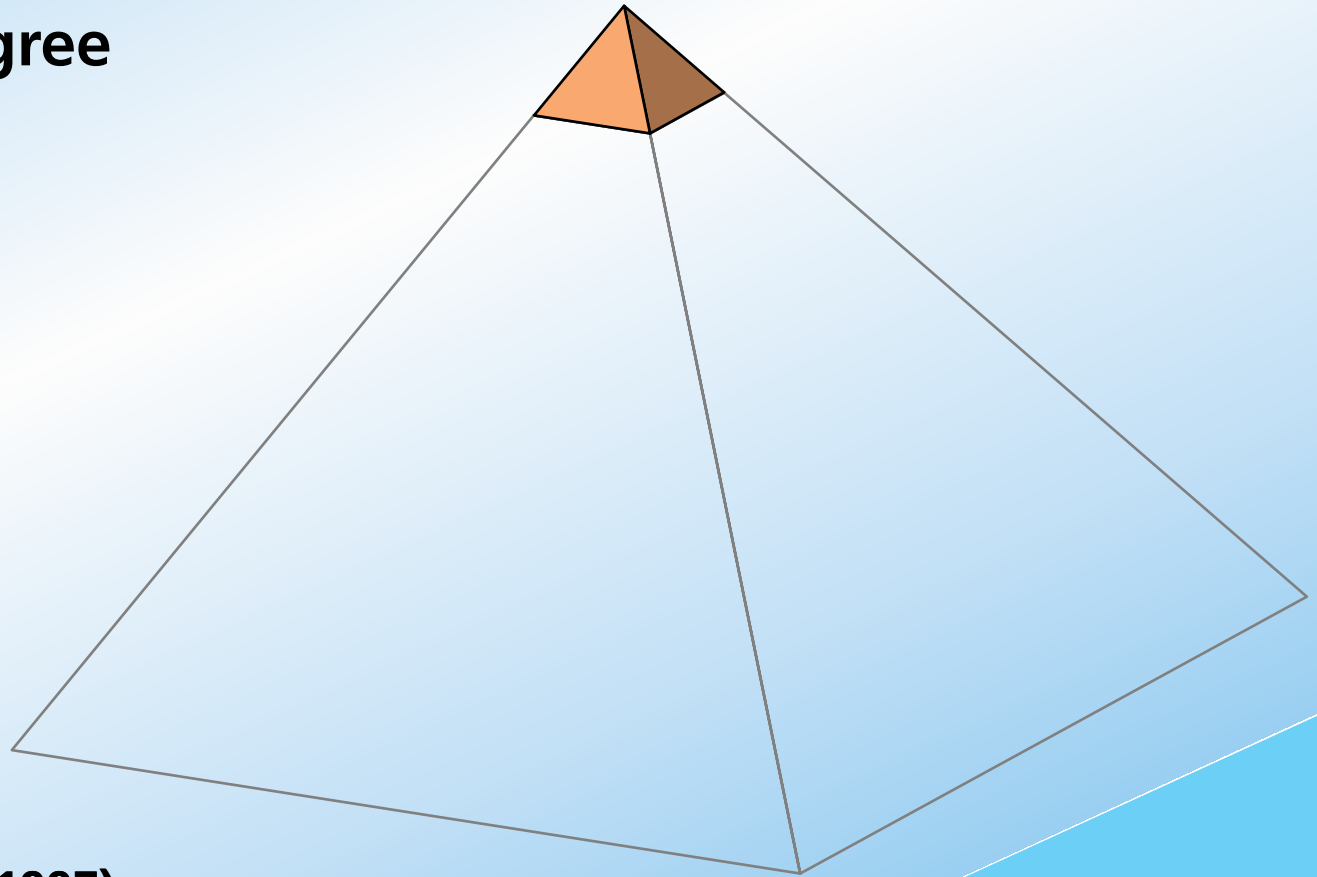
**about 1% of these get
a bachelor's degree
in physics**



AIP Report R-151.33 (1997)

We have a problem

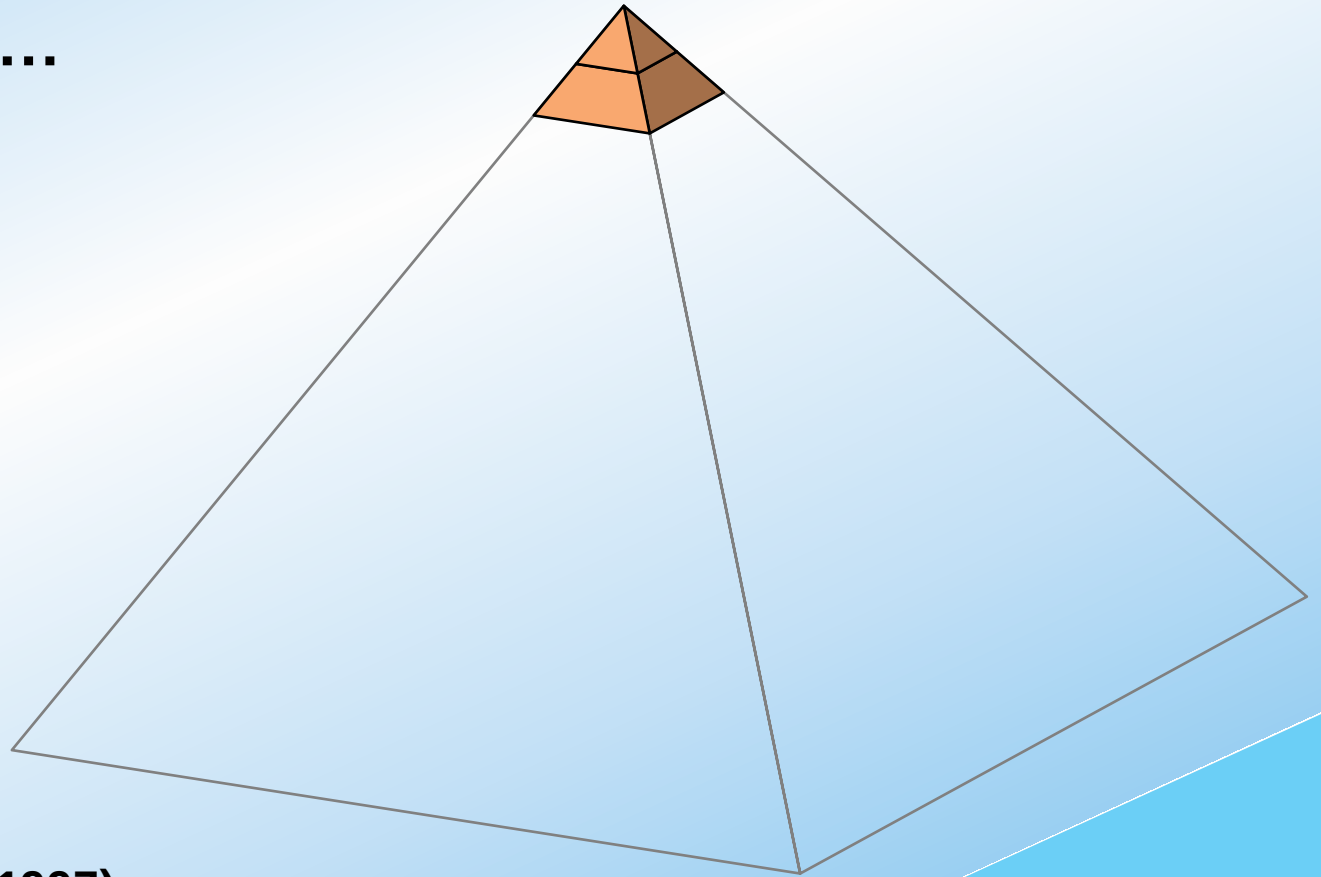
**Of the 4,300 students with
a bachelor's degree
in physics...**



AIP Report R-151.33 (1997)

We have a problem

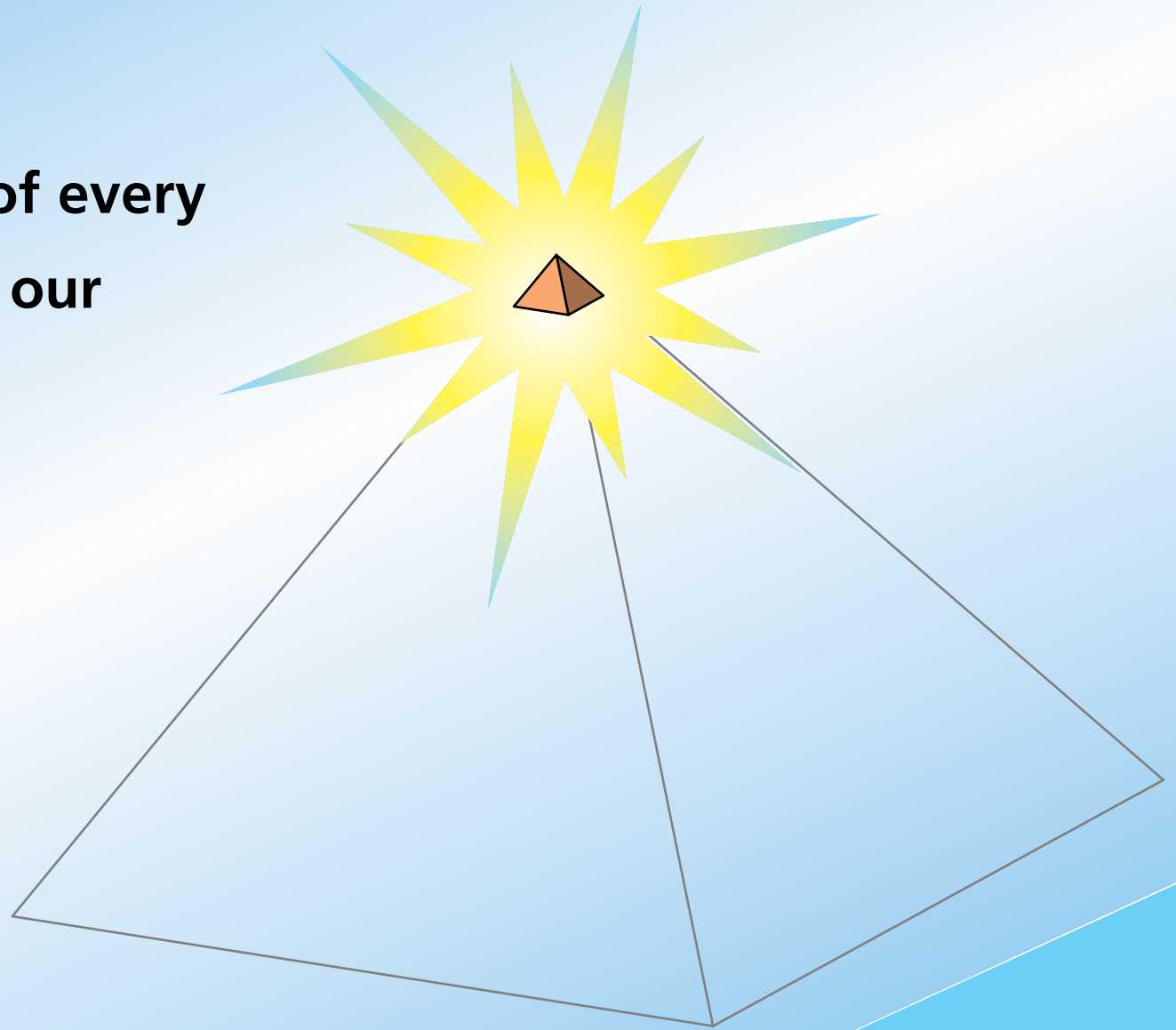
**about 35% go on to get a
Ph.D. in physics...**



AIP Report R-151.33 (1997)

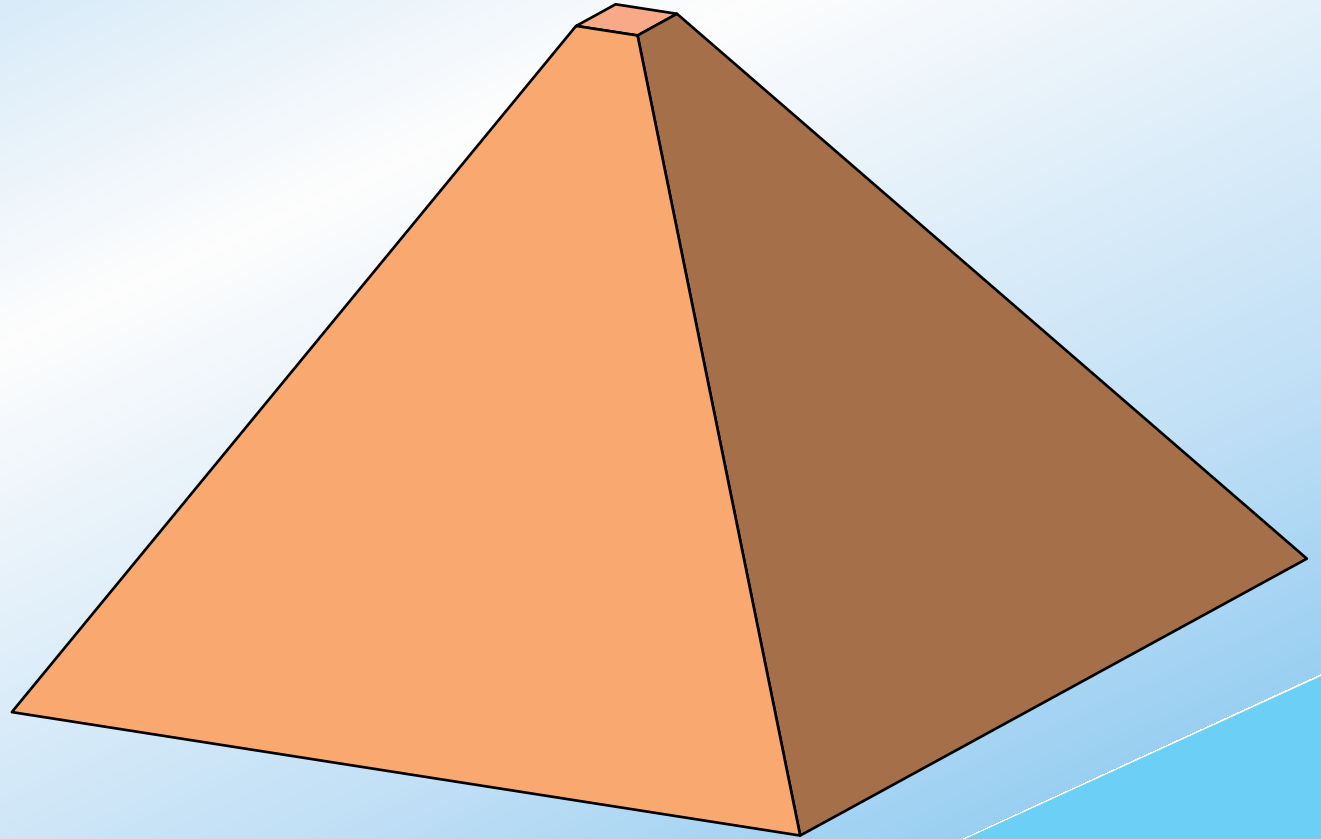
We have a problem

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



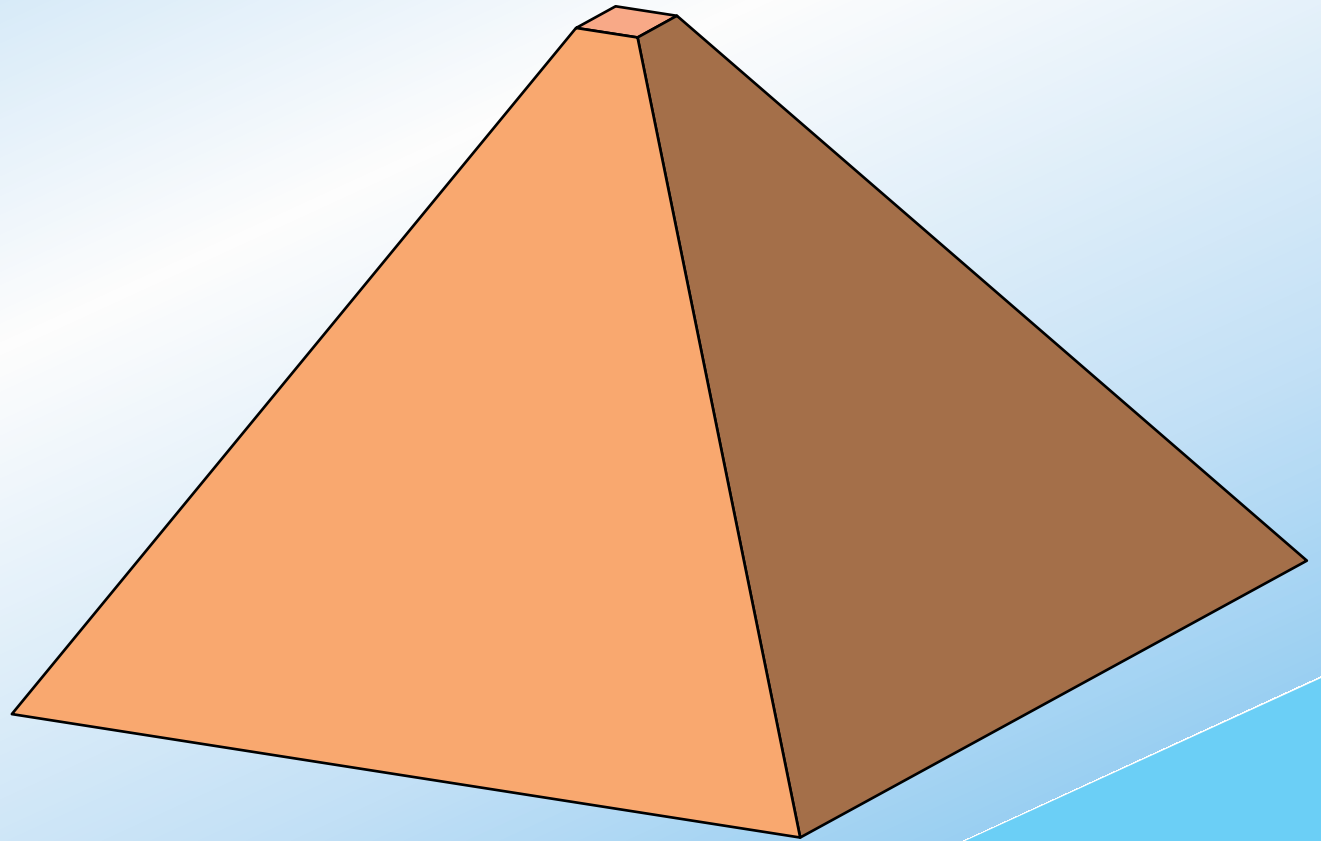
We have a problem

**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

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.

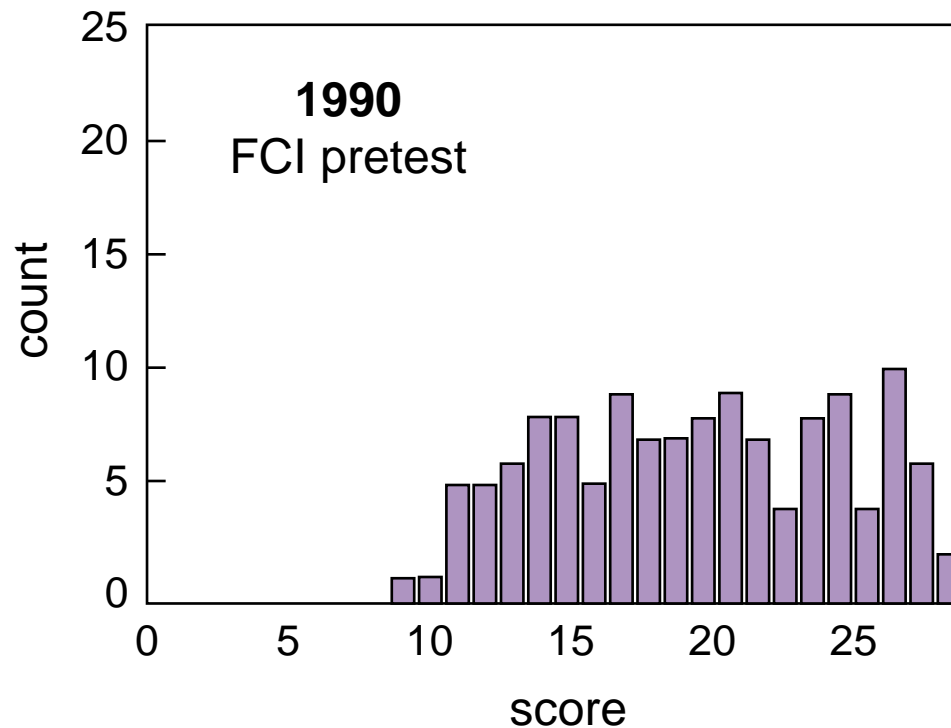
Why do we have this problem?

Why do we have this problem?

Lectures focus on transfer of information...

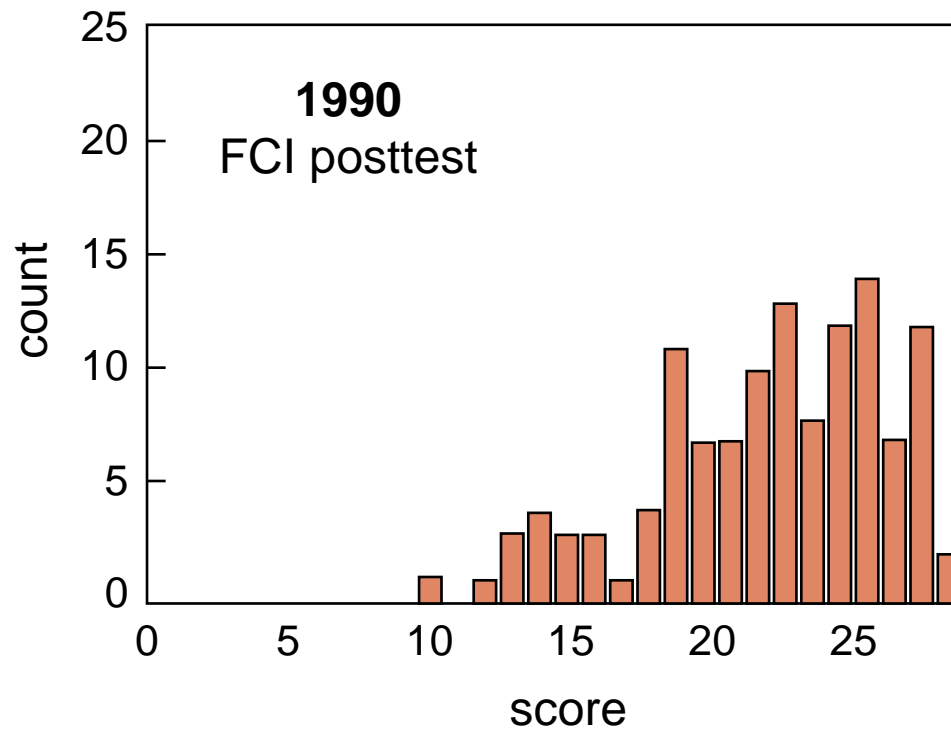
Why do we have this problem?

...but physics is not just information!



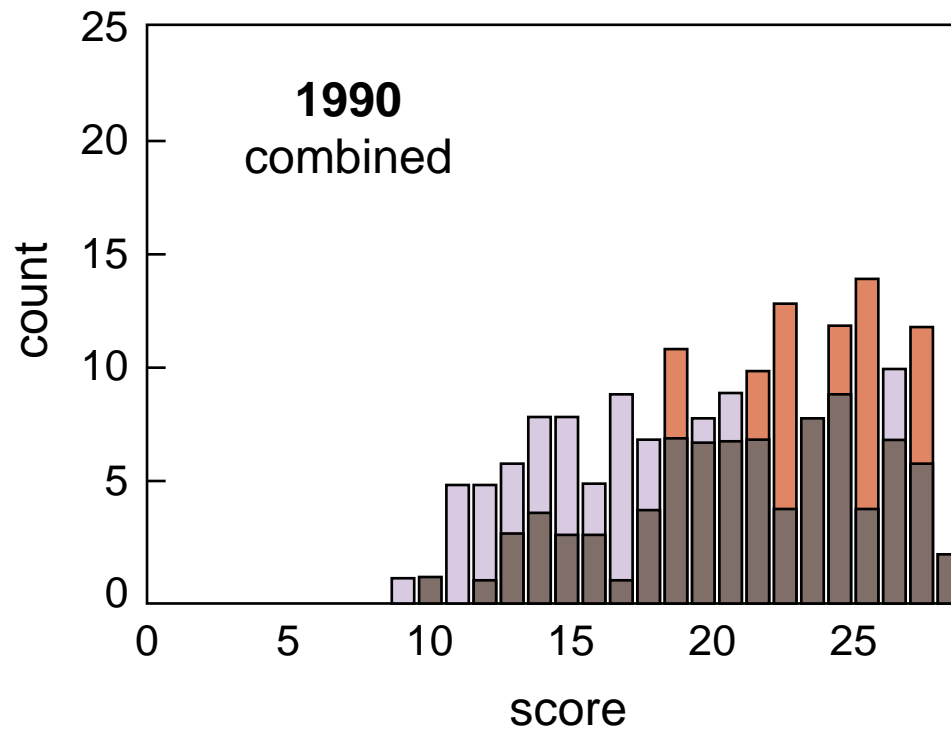
Why do we have this problem?

...but physics is not just information!

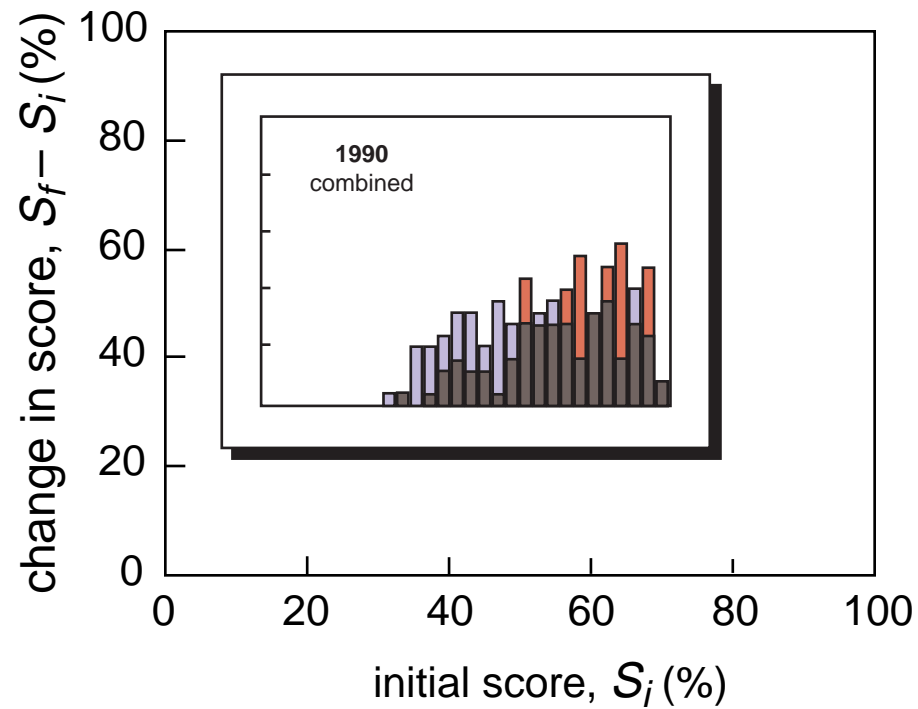


Why do we have this problem?

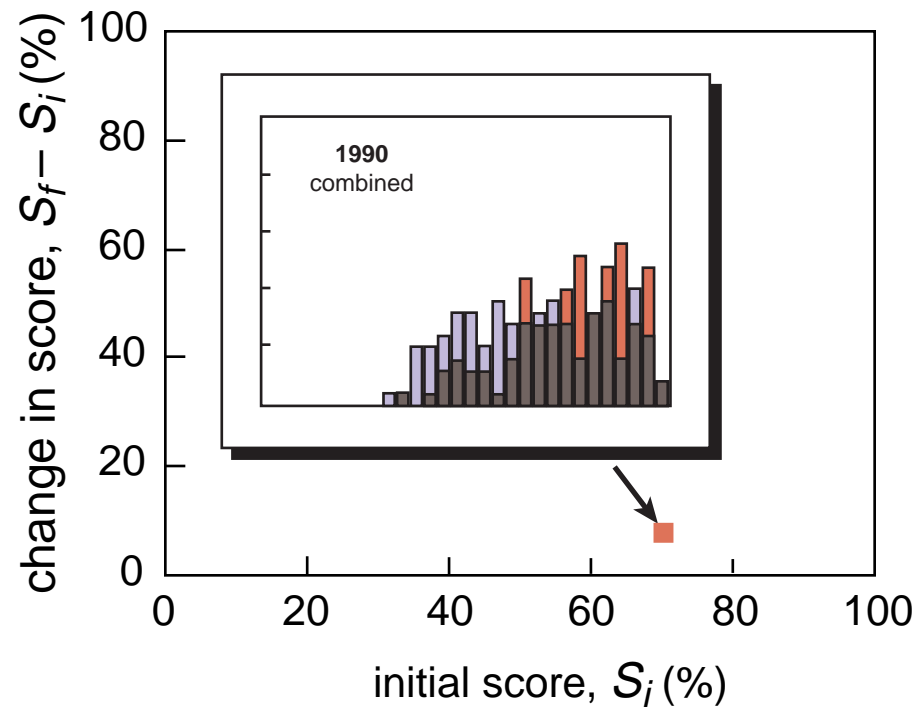
...but physics is not just information!



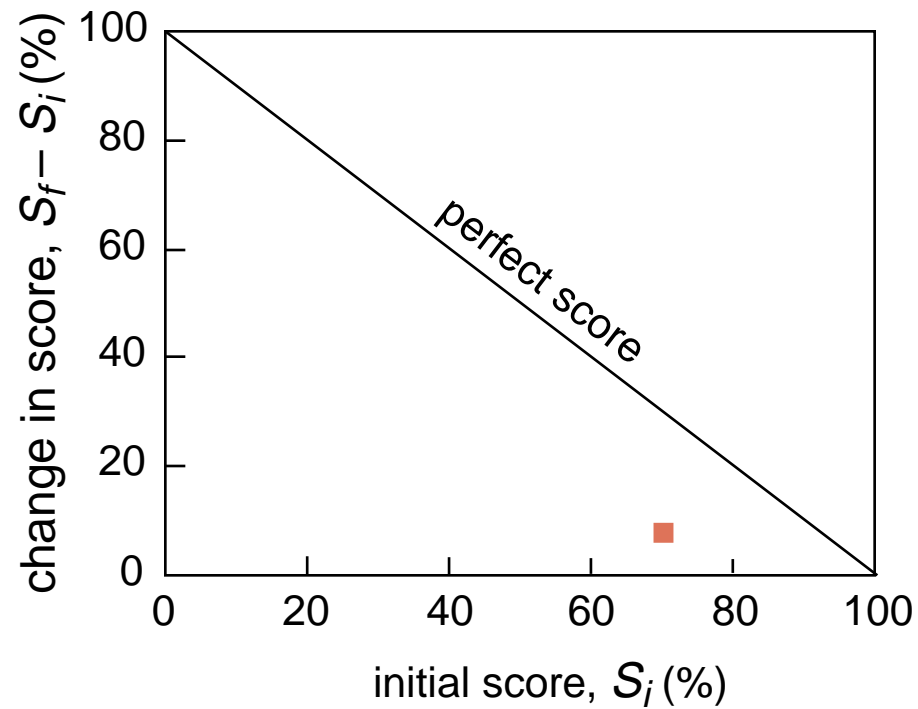
Why do we have this problem?



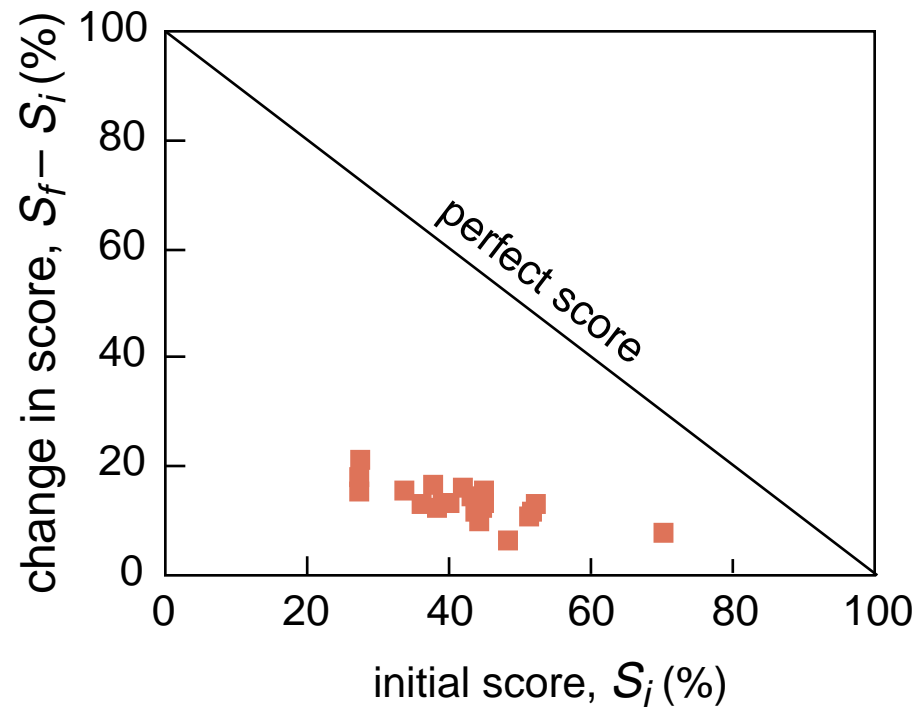
Why do we have this problem?



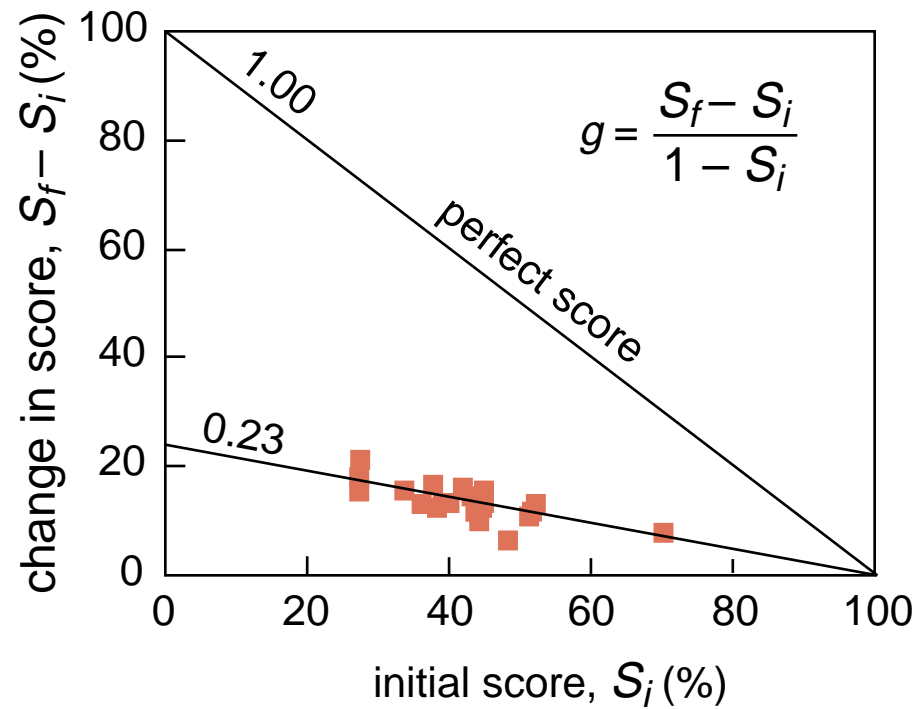
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Why do we have this problem?



Why do we have this problem?

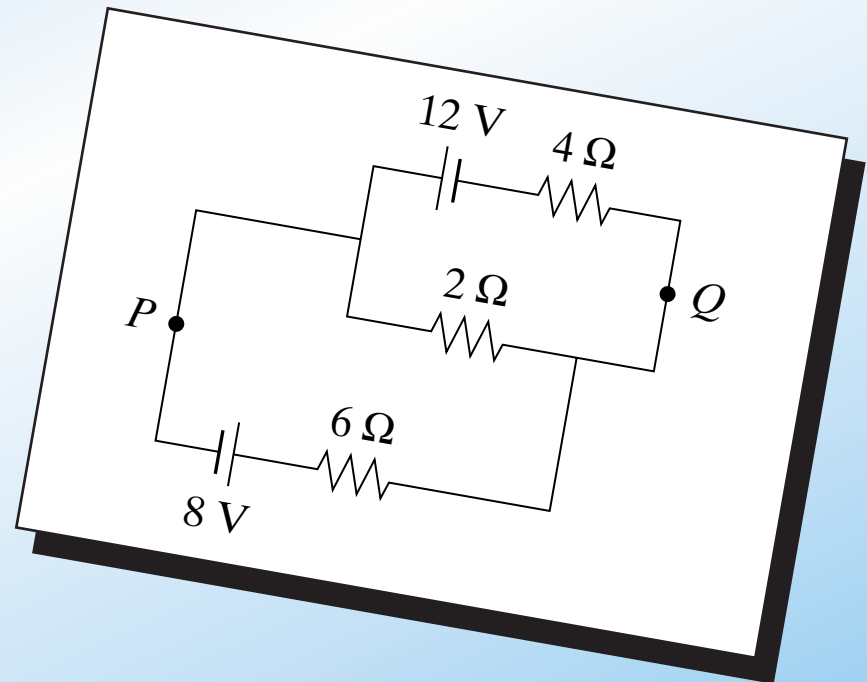


Why do we have this problem?

Conventional problems reinforce bad study habits

Why do we have this problem?

Conventional problems reinforce bad study habits

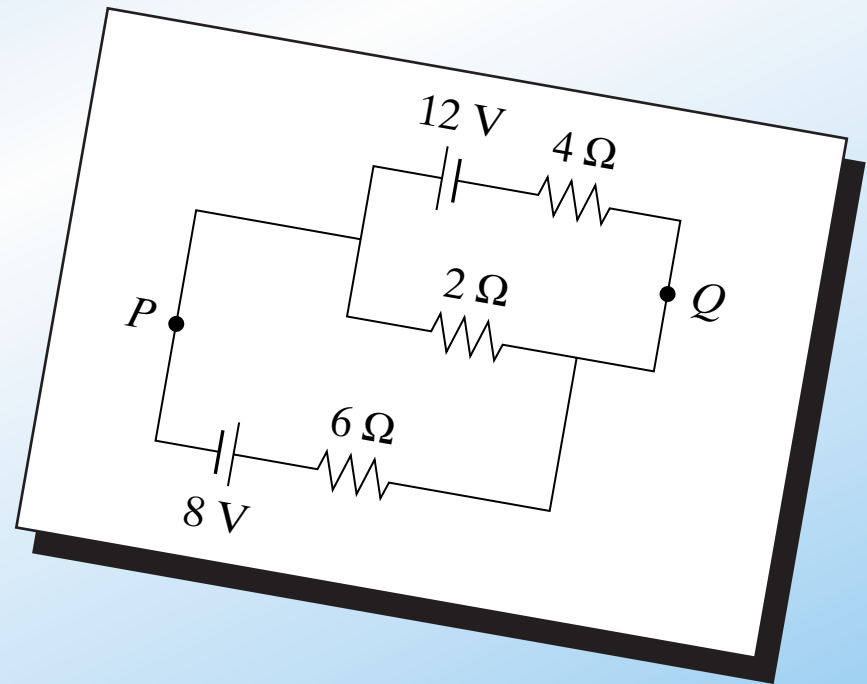


Why do we have this problem?

Conventional problems reinforce bad study habits

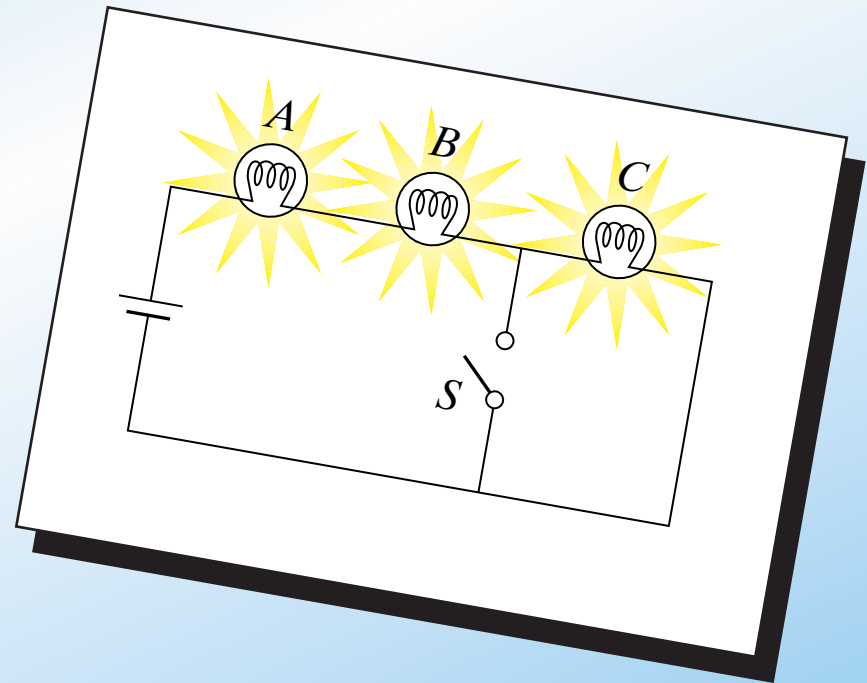
Calculate:

- (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?

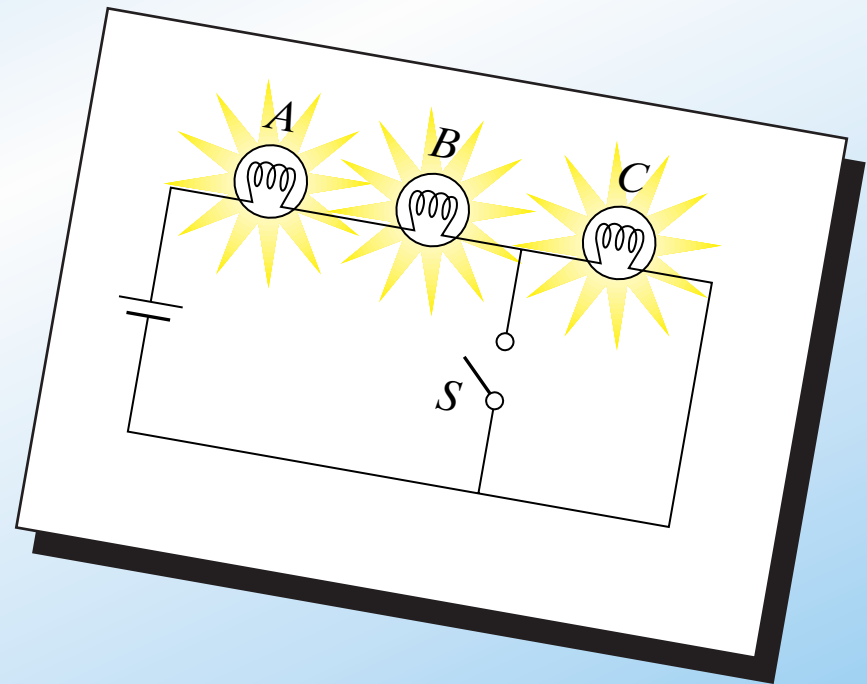


Why do we have this problem?

Are basic principles understood?

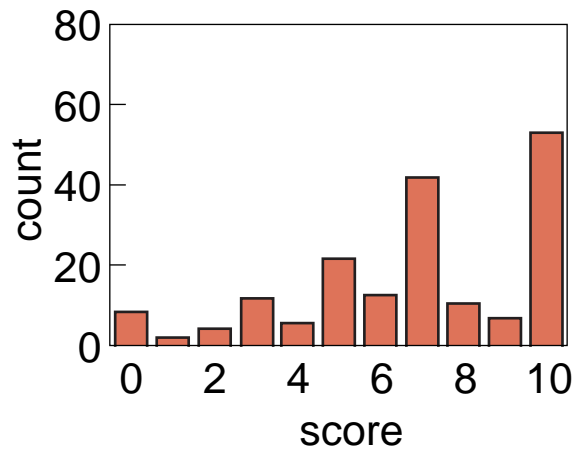
When S is closed, what happens to the:

- (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?

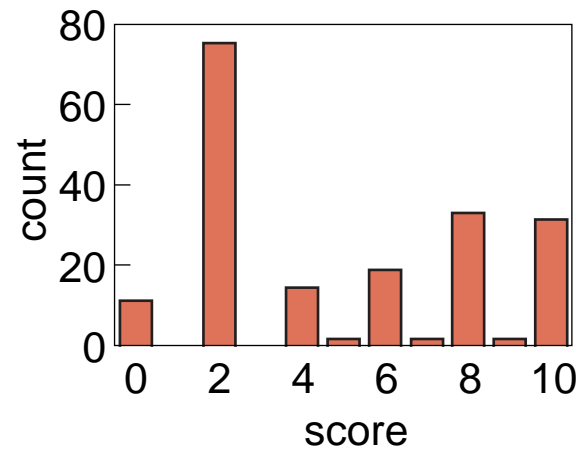


Why do we have this problem?

conventional

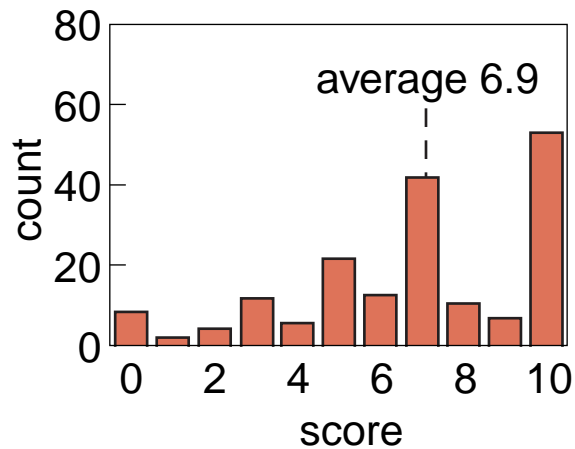


conceptual

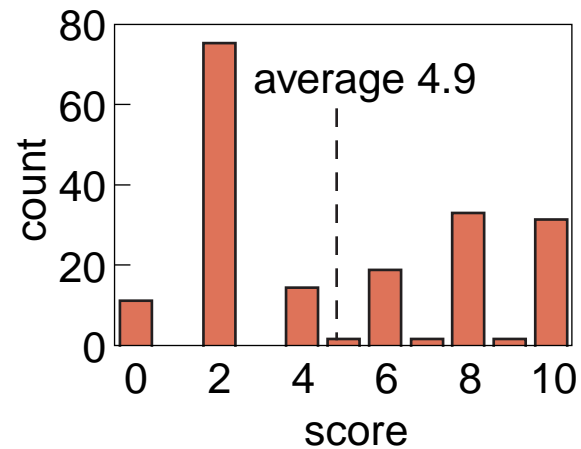


Why do we have this problem?

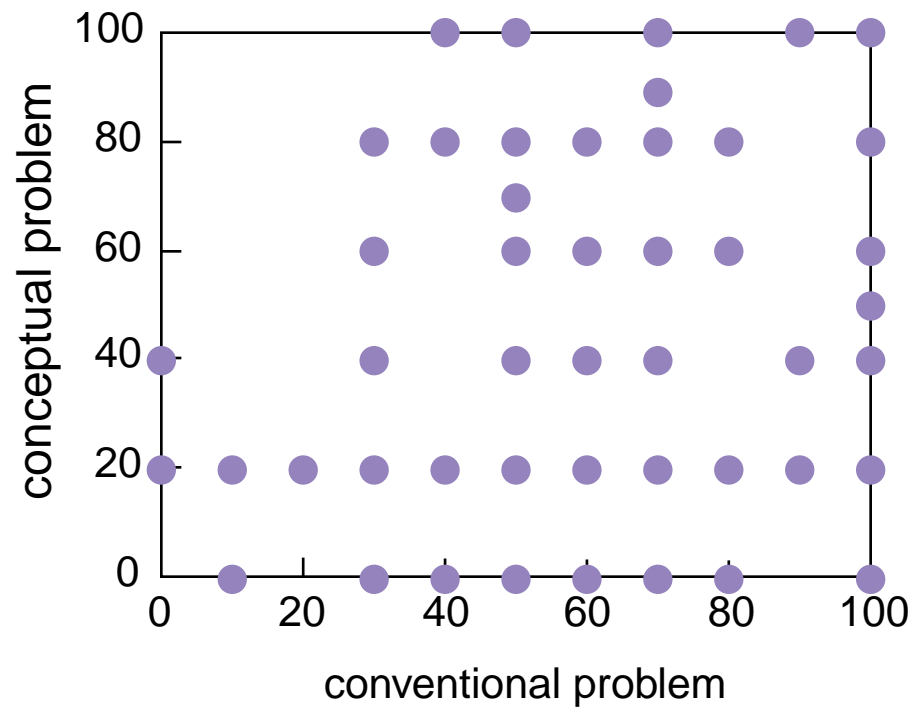
conventional



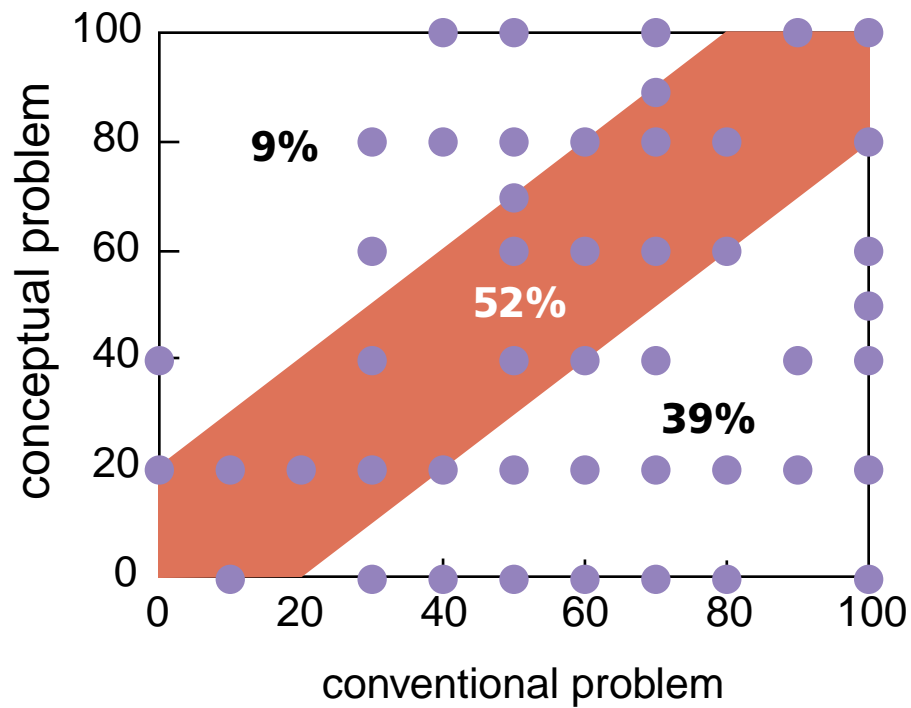
conceptual



Why do we have this problem?



Why do we have this problem?



A wide-angle photograph of a large lecture hall. The room is filled with students seated in rows of desks, facing the front. At the front of the hall, a professor stands behind a podium, addressing the class. A large projection screen at the front displays text, and a chalkboard is visible behind the professor. The text on the screen is partially legible and appears to be a list or a set of instructions. The overall atmosphere is that of a formal academic setting.

Peer Instruction

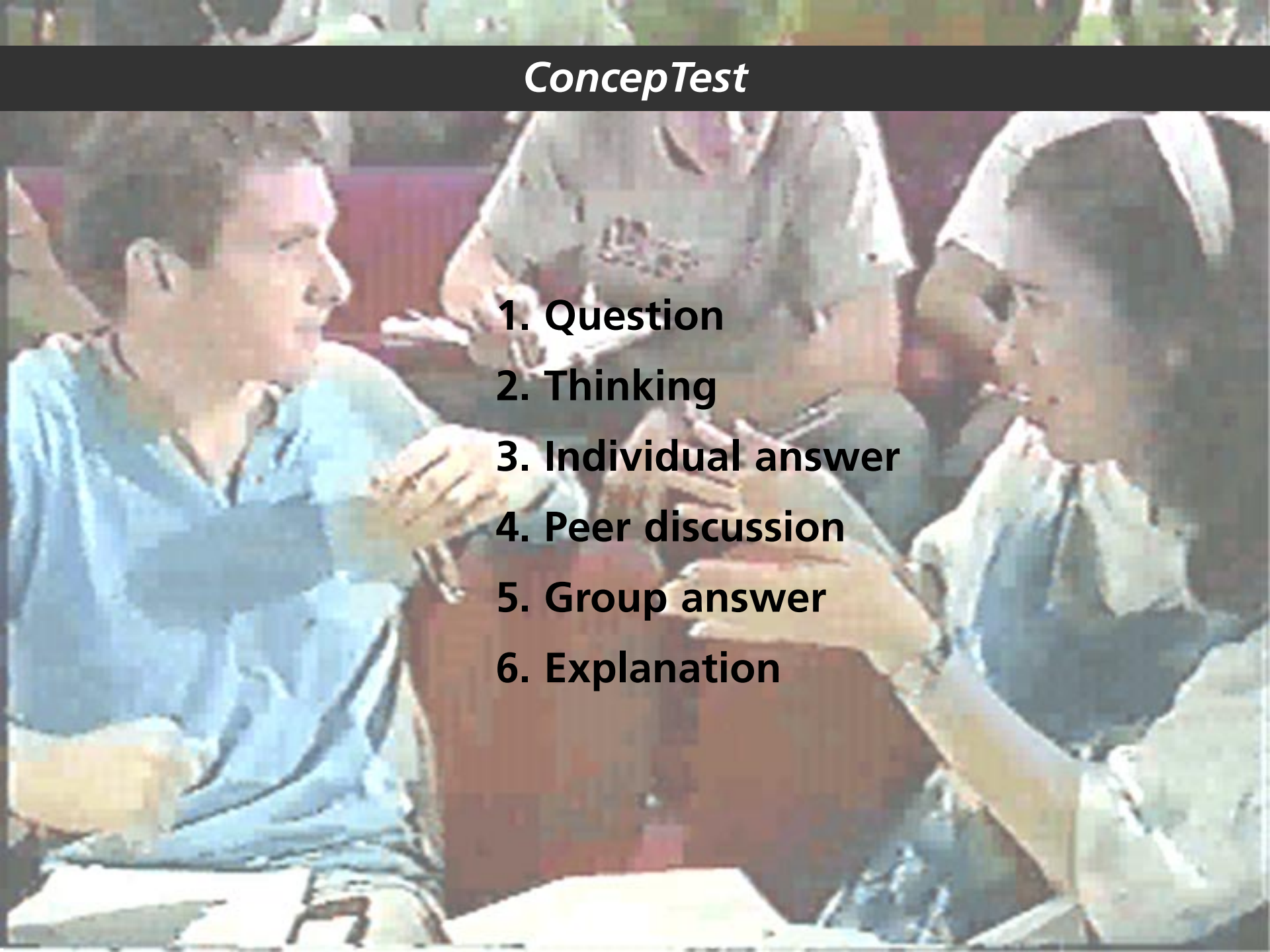
Help students take more responsibility for learning!

Peer Instruction

Main features:

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

ConcepTest

- 
- A photograph of three students in a classroom. A male student in a blue shirt is on the left, gesturing with his hands while speaking. A female student in a grey shirt is in the center, looking towards the male student. Another female student in a grey shirt is on the right, also looking towards the male student. They appear to be engaged in a discussion or a group activity.
- 1. Question**
 - 2. Thinking**
 - 3. Individual answer**
 - 4. Peer discussion**
 - 5. Group answer**
 - 6. Explanation**

Is it any good?

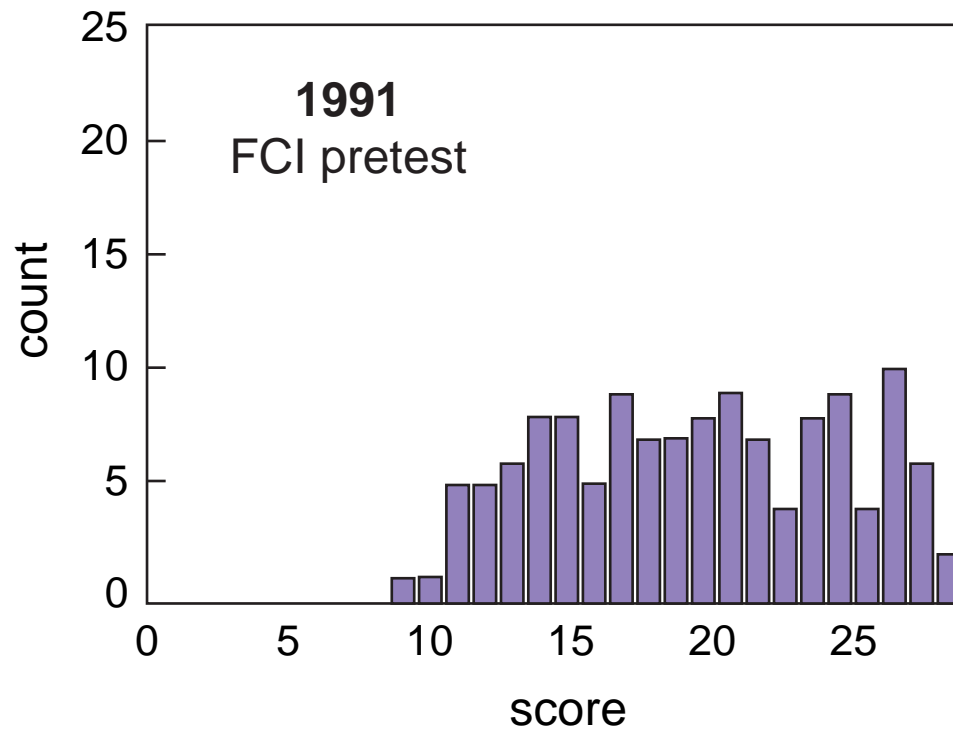
Is it any good?

► **Results**

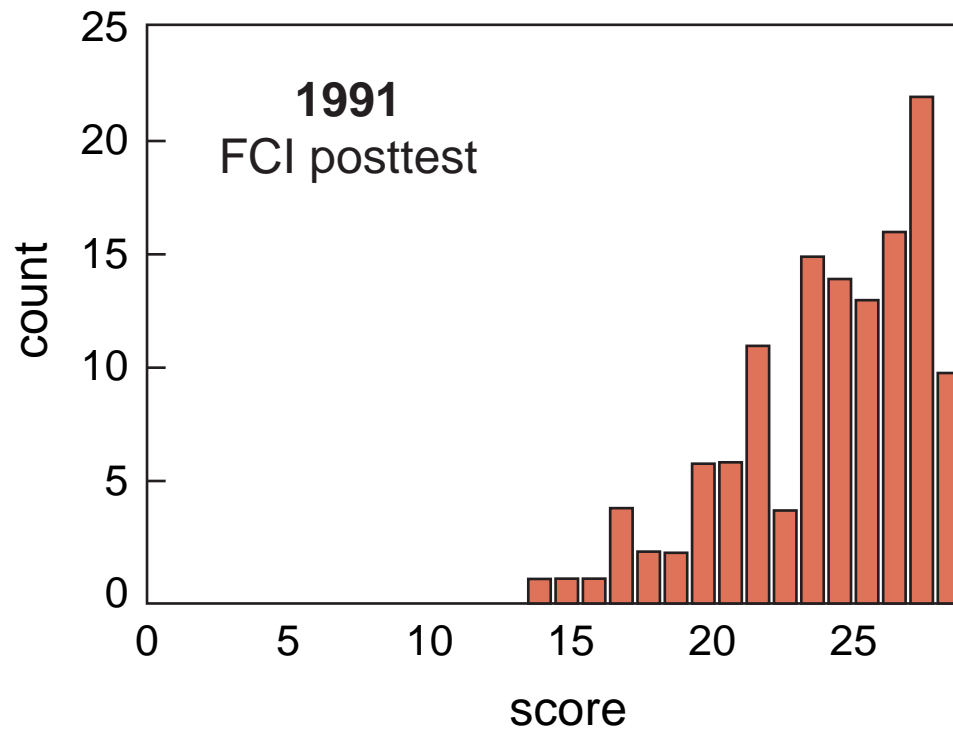
Is it any good?

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

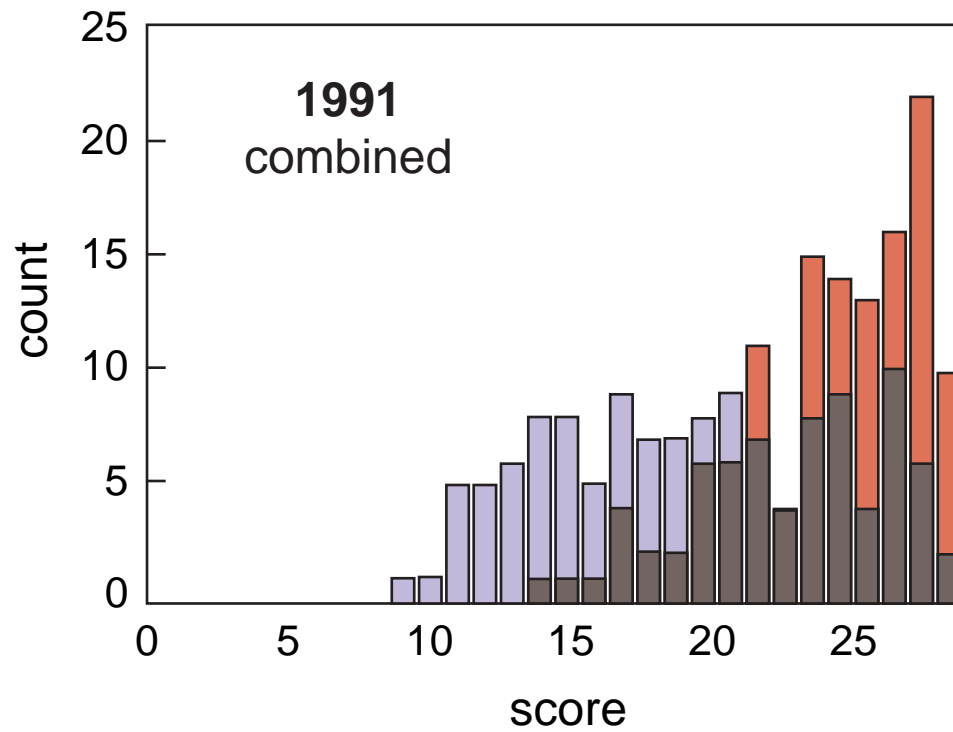
Results



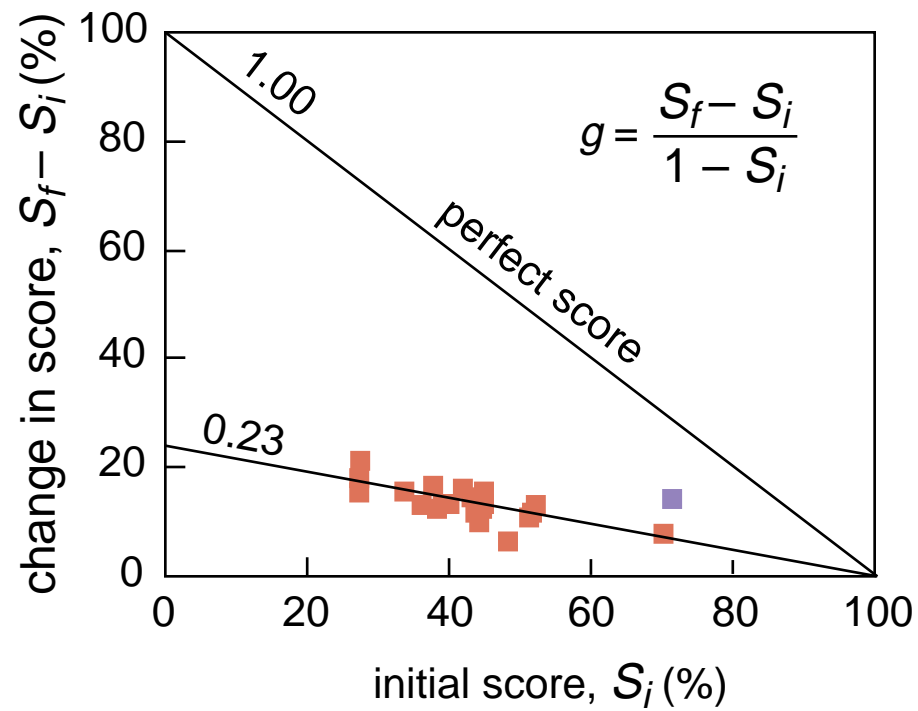
Results



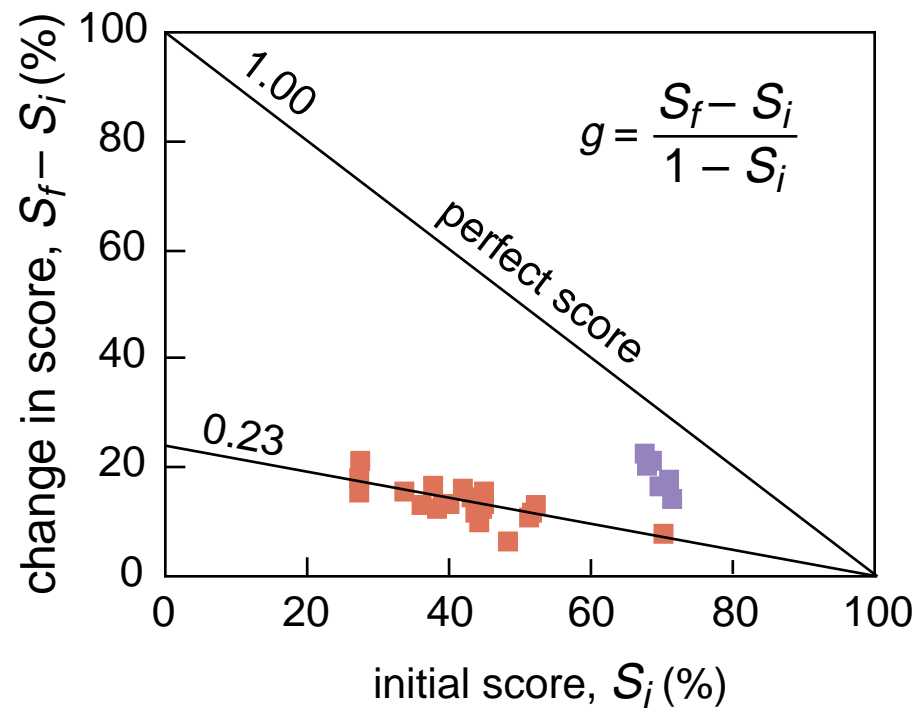
Results



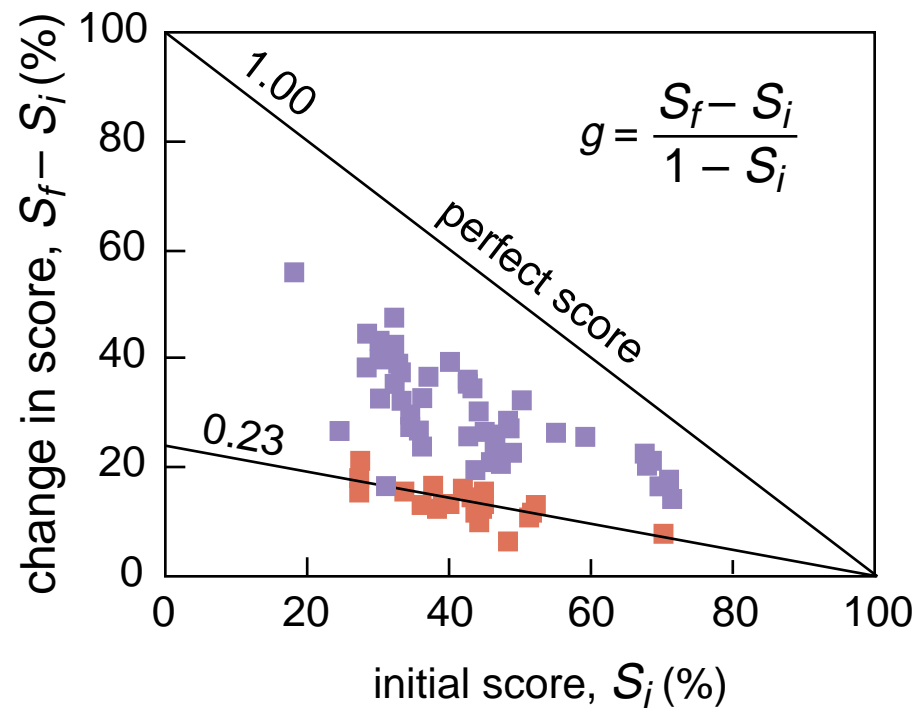
Results



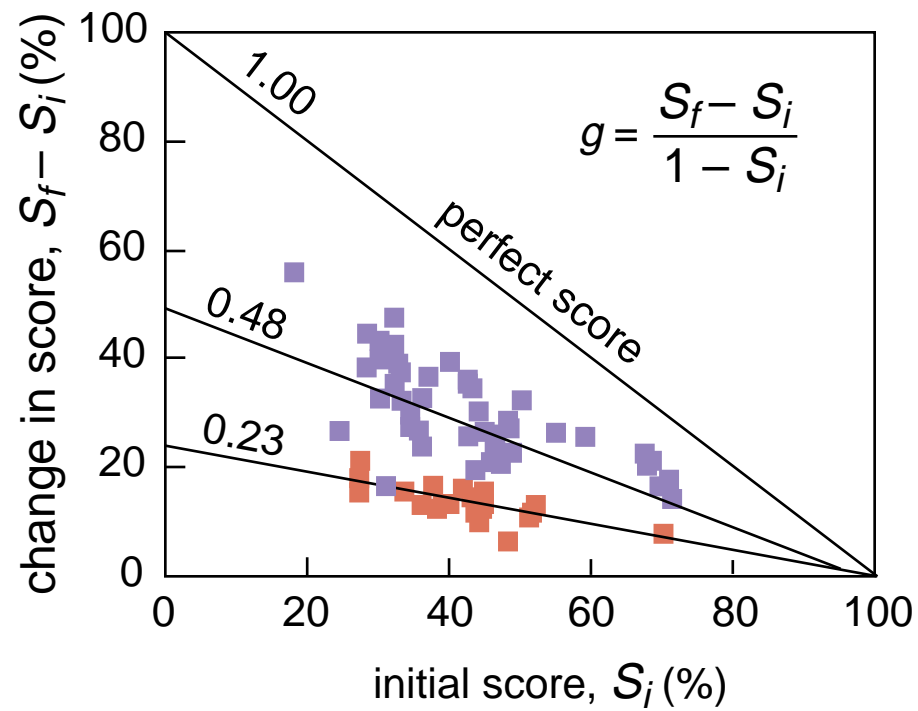
Results



Results



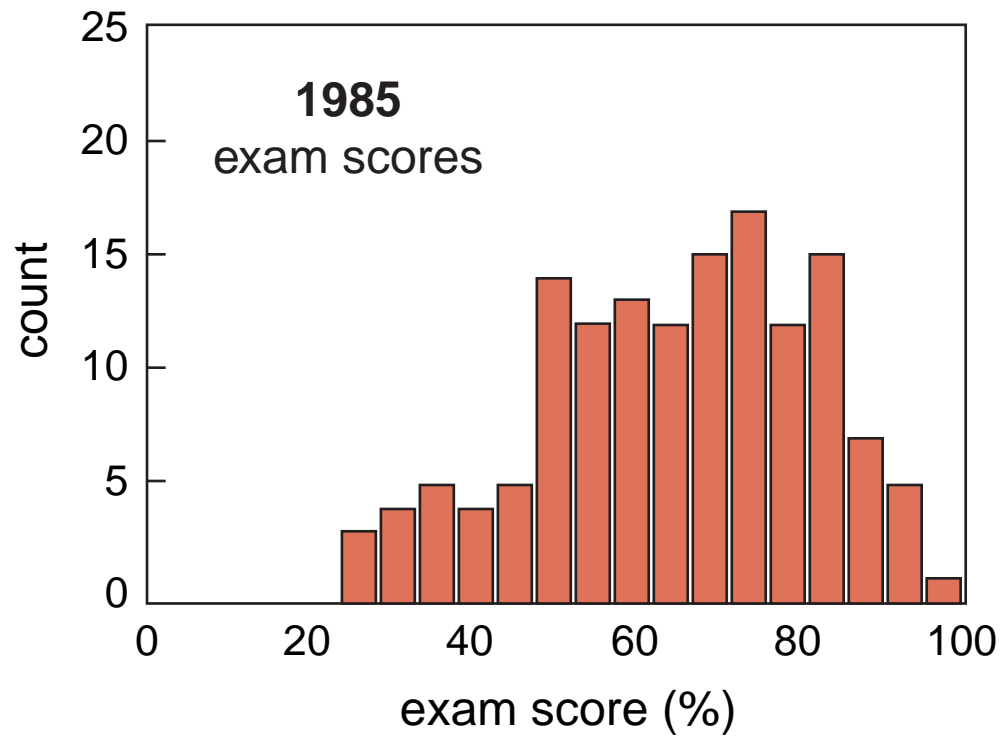
Results



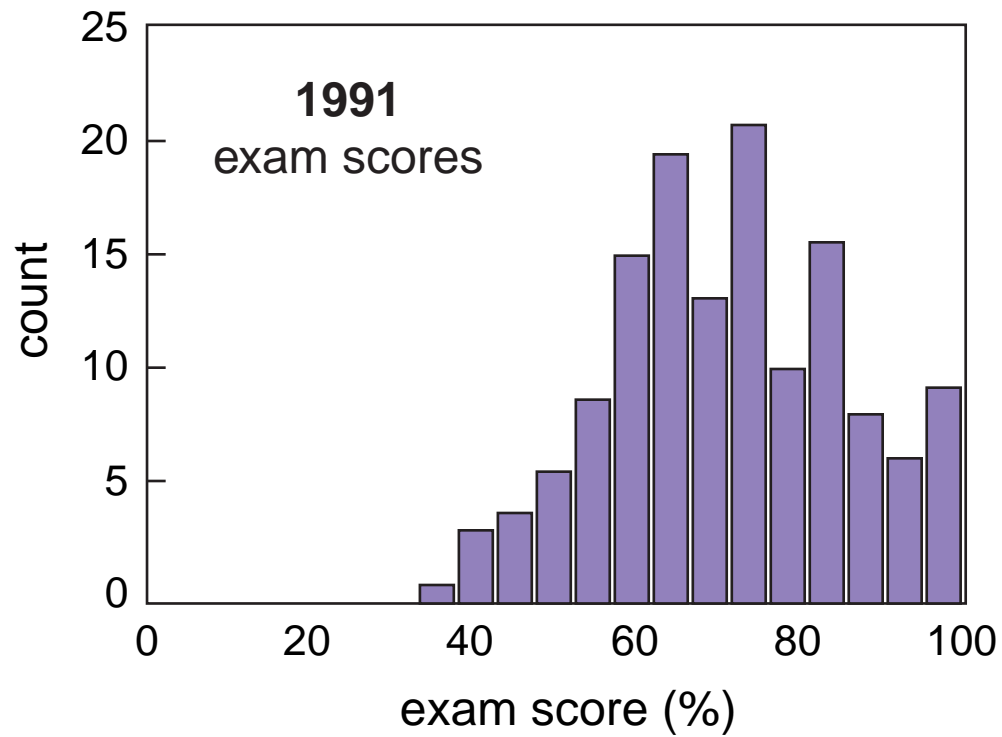
Results

What about problem solving...?

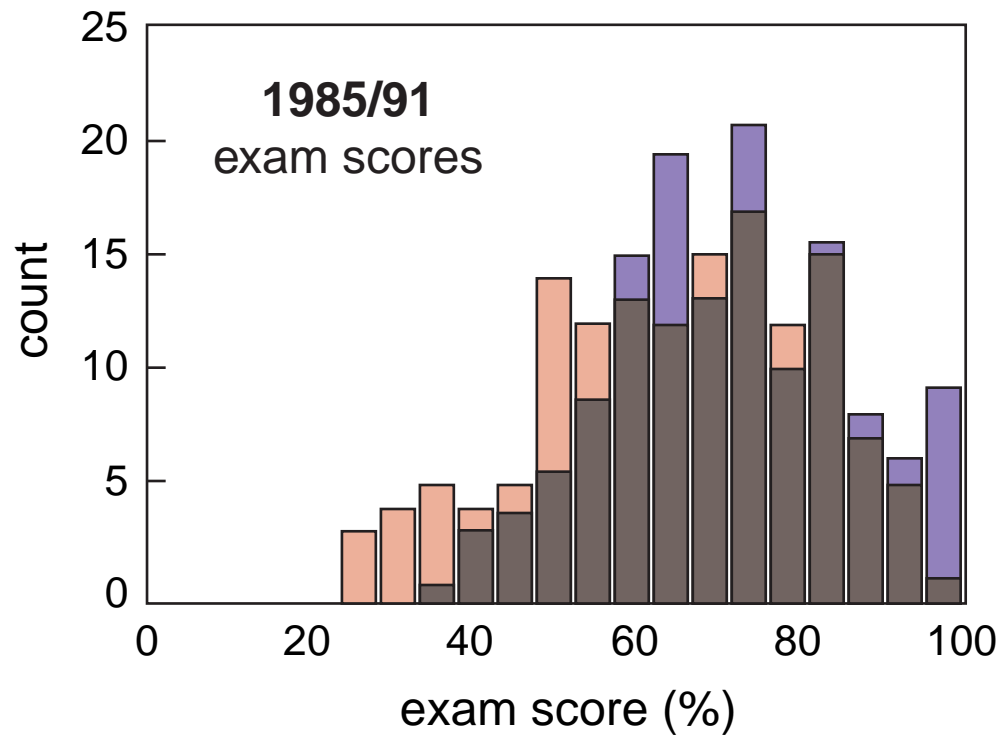
Results



Results



Results



Results

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

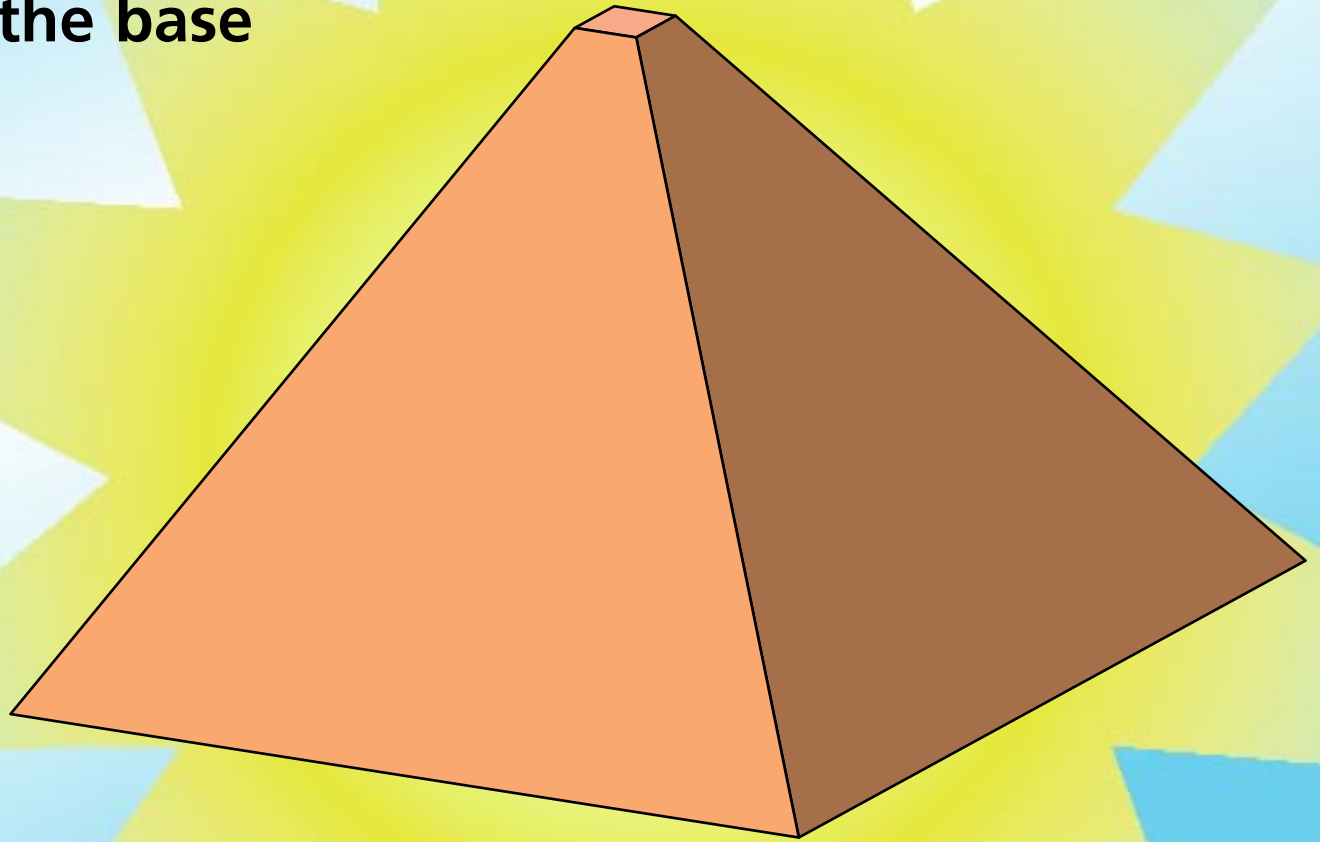
Results

So better understanding leads to better problem solving!

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

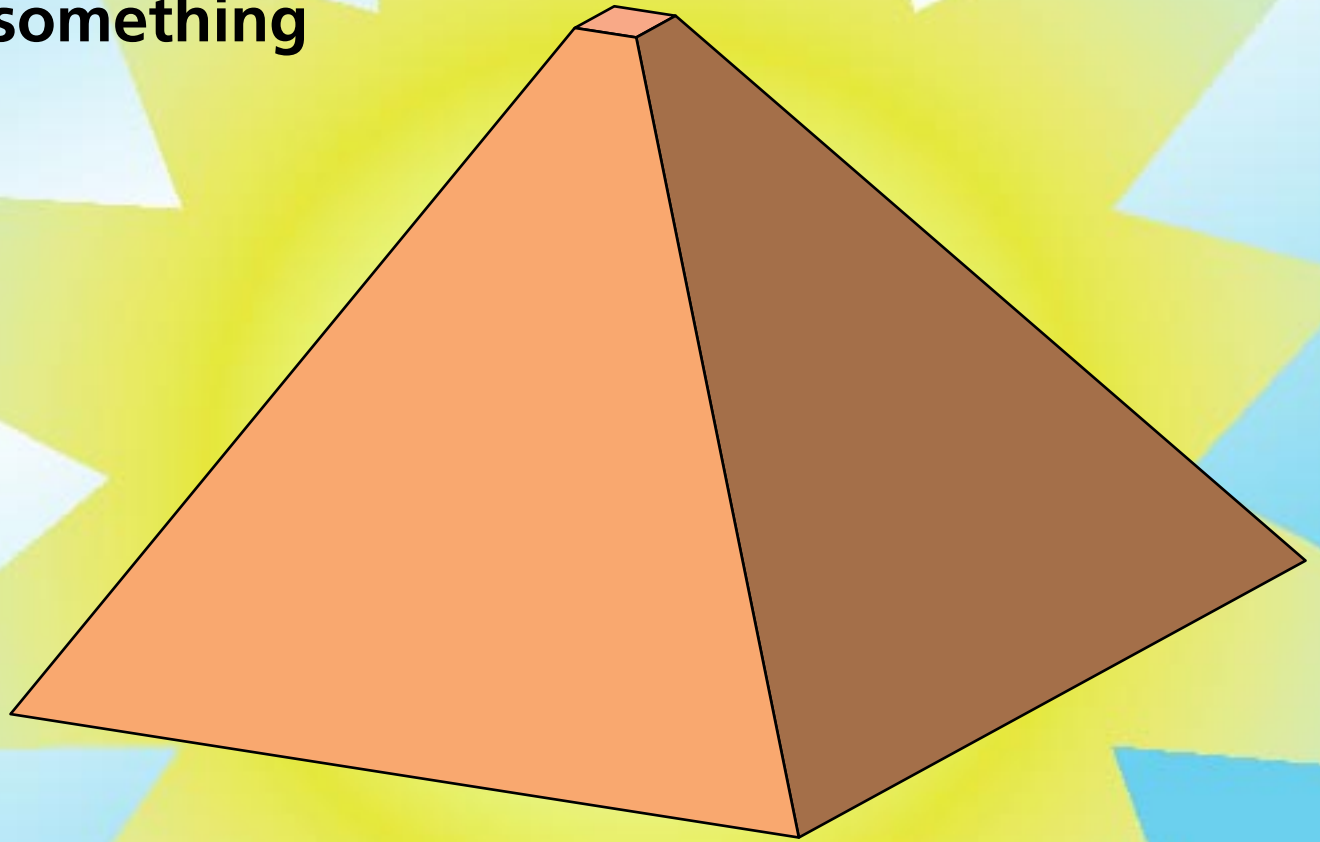
Conclusion

**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>