The Science and the Art of Teaching

In recent years, science educators have achieved a broad consensus on how students learn. But there are many different visions of how to put these ideas into practice. I will share some of the relevant theory, some of the relevant experiments, the use of different educational technologies, and some practical tips for designing an effective college course in a typical institutional setting with real constraints on time and resources.

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Part I:

My background & experience
Lessons learned
A bit of theory

All I Need to Know about Science Teaching I Learned in Kindergarten.

From

All I Need to Know I Learned in Kindergarten

by Robert Fulghum

Play fair.

Don't hit people.

Put things back where you found them.

Say you're sorry when you hurt somebody.

Wash your hands before you eat.

Take a nap every afternoon.

When you go out into the world, watch out for traffic, hold hands, and stick together.

Different Facets

School programs

Television program

Teacher workshops

Podcasts

International programs

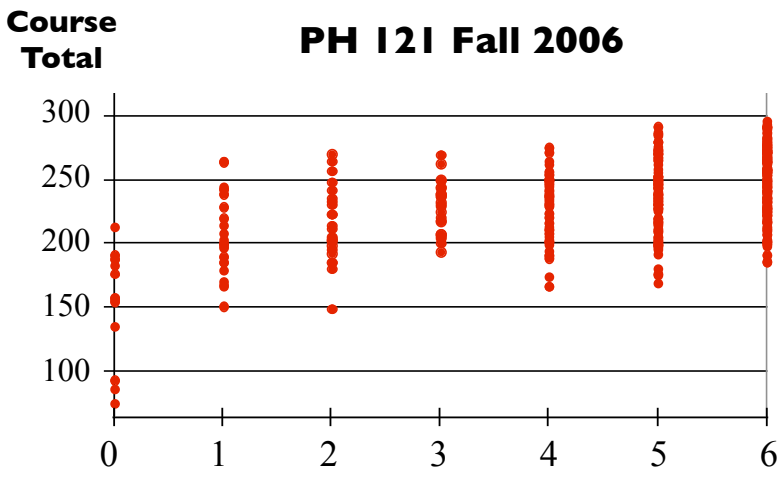
Extended road trips

Annual Open House

All I Need to Know...

The world is comprehensible, and you can learn about it by exploring.

We learn best when we are active.



Active Participation is A Good Thing.

Conventional Instruction

A ball is tossed straight up; it rises and then falls. After the ball has left the thrower's hand and is headed upward,

A. The net force is directed upward.

B. The net force is directed downward.

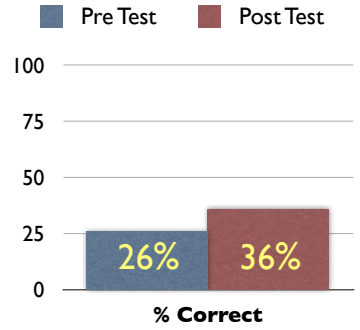
C. There is no net force.

CSU Introductory Physics for Scientists & Engineers, Fall 1991

Pre Test: All students, at start of course.

Post Test: All students, after six weeks of mechanics instruction.

Note: Students in the class had done well on quantitative problems regarding tossed and dropped objects.



Conventional (lecture-dominated) instruction shows little effect on student learning of basic concepts in the introductory course.

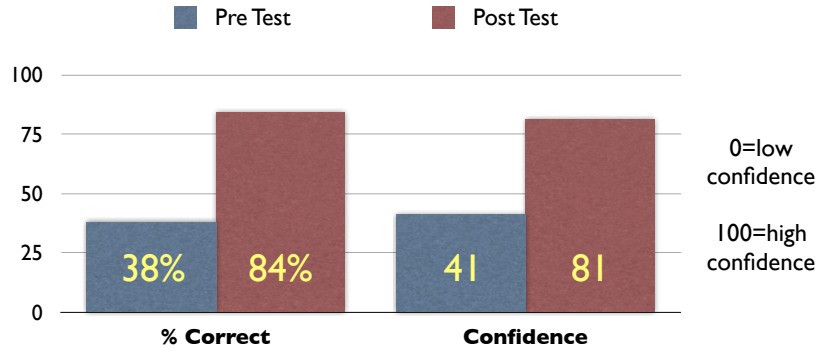
Basic Science Concepts

On a cool night, dew condenses on the roof of your car.

As the water vapor condenses to make the droplets of liquid water that you see as dew,

A. Heat energy is transferred to the roof of your car, warming it.

B. Heat energy is transferred from the roof of your car, cooling it.



Simple Tools for "Activating" the Class

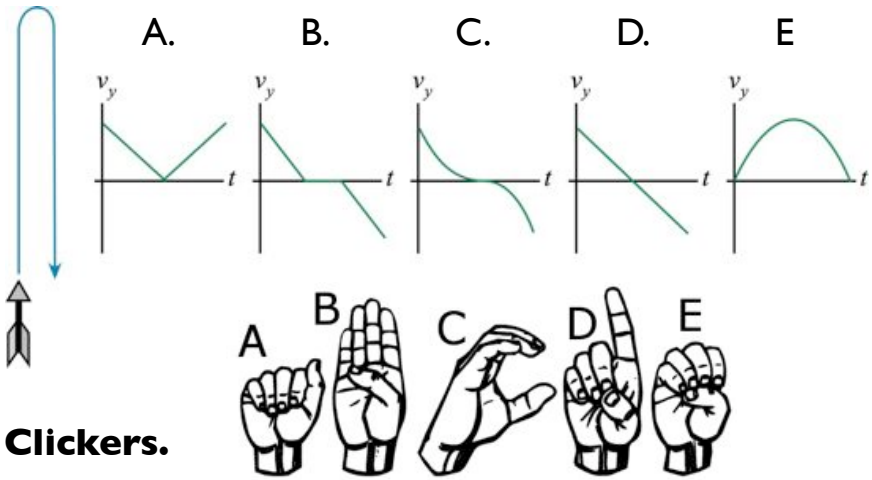
Physics Theater

Desktop Experiments

Class Questions

What is the problem to which technology is the solution?

An arrow is launched vertically upwards. It moves straight up to a maximum height, then falls to the ground. The trajectory of the arrow is noted. Which graph best represents the vertical velocity of the arrow as a function of time? Ignore air resistance.



Clickers.

Scenario #5: Force to Drive Car on Highway

Forces

Weight Drag Normal Friction

Details

Driving a Corvette on the highway.
Details:

- 20 m/s (about 45 mph)
- Frontal area: 1.8 m^2
- Drag coefficient: 0.30

What is the force required to keep the car moving forward?

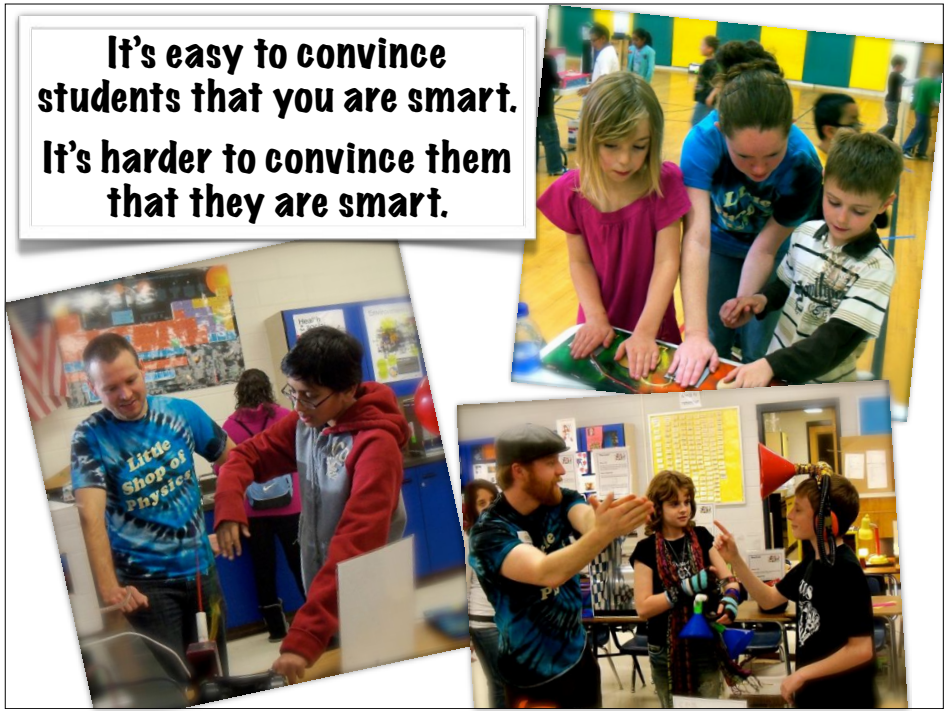
Photos

Sound & Music

If a sliding board makes an angle of 60 degrees with the ground and the coefficient of sliding friction between the kids and the sliding board is 0.15, at what rate will they accelerate?

It's easy to convince students that you are smart.

It's harder to convince them that they are smart.



Our job is to design an environment in which students can learn.

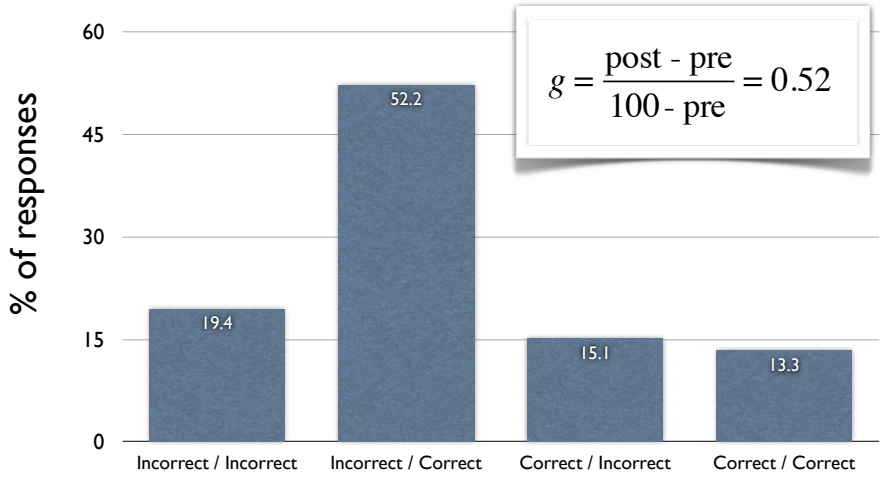
The Way the Wind Blows

In Colorado, sometimes the wind blows from high elevations and low pressures in the mountains to low elevations and high pressures on the plains.

As the air does this, it:

A. cools down.
B. warms up.

Comparing pre-test / post-test data



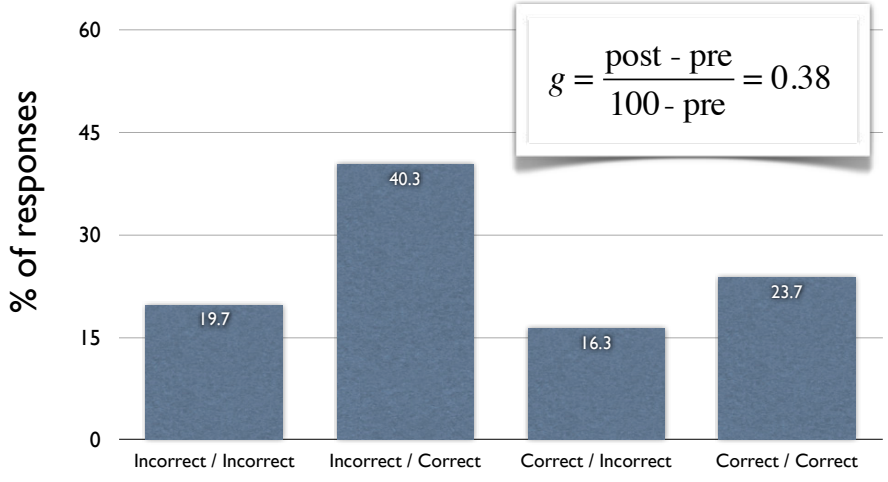
Data from Columbia Middle School
17 Feb 2011

Photon Energy

Which type of light has the highest energy photons?

A. Red light.
B. Blue light.

Comparing pre-test / post-test data



$$g = \frac{\text{post - pre}}{100 - \text{pre}} = 0.38$$

Data from Columbia Middle School
17 Feb 2011

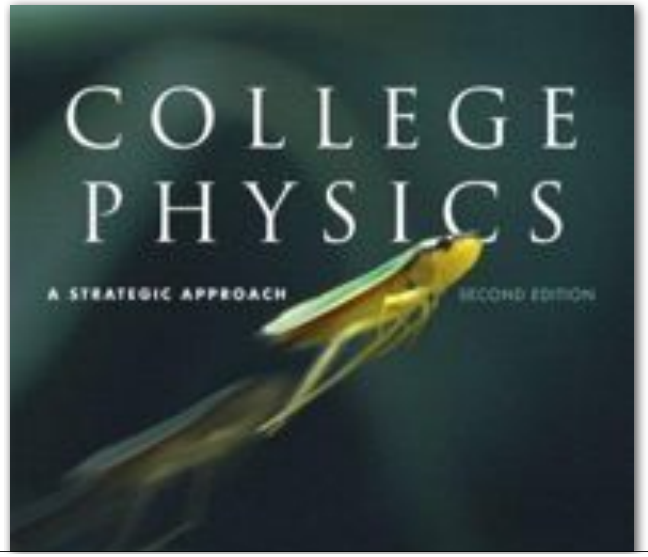
Qualitative Observations

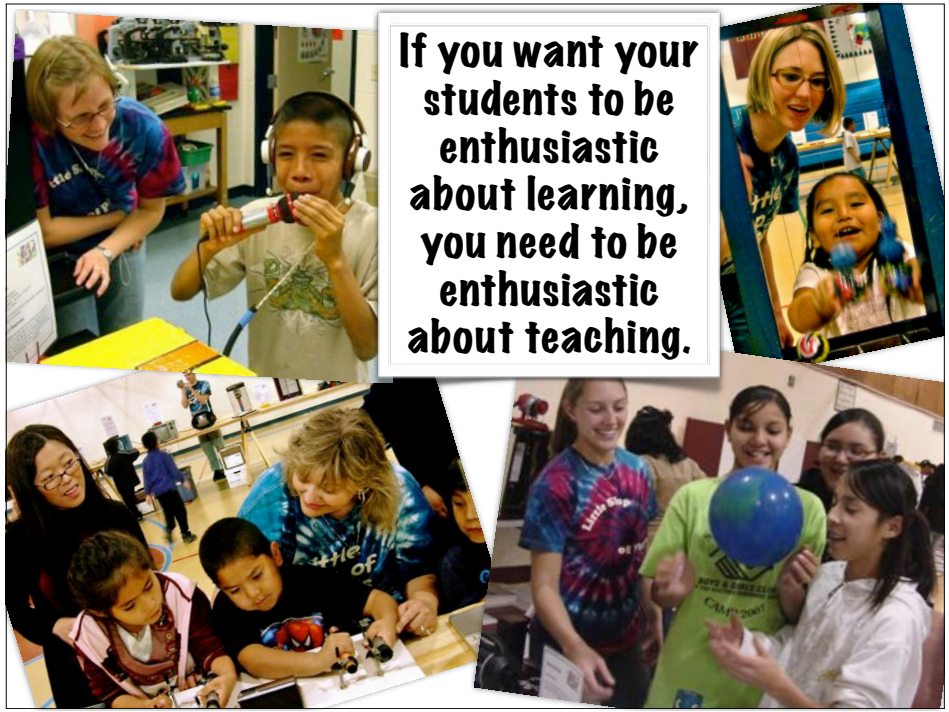
- 6th - 7th grade: Most effective.
- No significant gender or ethnic differences.
- 15 seconds.

Why have class at all?

Class is about communication.

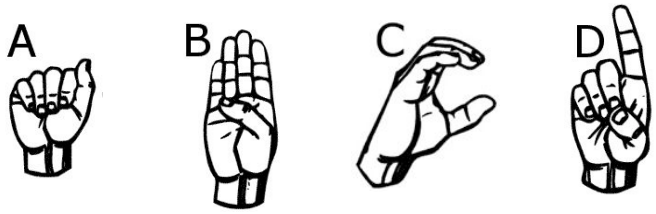
In surveys of introductory physics courses, what was the best predictor of success?





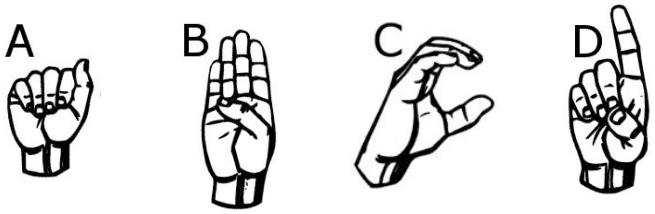
To improve course evaluations and improve student learning, which of the following changes, by itself, is likely to make the biggest difference?

A. Assigning more lengthy homework assignments.
B. Changing the textbook from a "standard" book to one based on recent research results.
C. Reducing class size from 50 to 30.
D. Taking acting lessons.



Which of the following changes in your teaching is likely to make the biggest difference in student achievement?

A. Assigning online reading quizzes for students to complete before coming to class.
B. Posting class notes online.
C. Posting audio podcasts of your lectures.
D. Learning the names of your students.



All I Need to Know about Science Teaching I Learned in Kindergarten.

The world is comprehensible, and you can learn about it by exploring.

We learn best when we are active.

You can understand something better if you can touch it.

To make it stick, make it real.

It's easy to convince students that you are smart. It's harder to convince them that they are smart.

Our job is to design an environment in which students can learn.

If you want your students to be enthusiastic about learning, you need to be enthusiastic about teaching.

Part II:

Practical tips.

Part III:

Examples.