Effective use of wireless student response units ("clickers")

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I. How much do students learn in lectures?

We've been teaching the same way for a long time…

Figure 1a. 2000 years ago

Figure 1b. Today.

But how well do students learn in a lecture setting?

The following example is from Carl Weiman. A Nobel Prize winner in physics AND a good teacher, in his "Physics of Everyday Life" class he teaches how a violin works. He points out that the body of a violin is essential for amplifying the sound of the strings. Most students have the misconception that the strings make all the sound:

"Explaining about sound and how a violin works, I show class a violin [Figure 2] and tell them that the strings cannot move enough air to produce much sound, so actually the sound comes from the wood in the back I point inside violin to show how there is a sound post so strings can move the bridge and the sound post causes back of violin to move and make sound. **15 minutes later** in the lecture I asked students a question -- the sound they hear from a violin is produced by 1. mostly strings, 2. mostly by the wood in the violin back 3. both equally, 4. none of the above."

The relevant question for you at this ASP meeting: What fraction of students do you think answered the multiple-choice question correctly?

a. 0%
b. 10%
c. 30%
d. 70%
e. 90%

The correct answer is (b): **Only 10% of the students answered correctly, 15 minutes later in the same lecture!**

That was an anecdote, but there is much data to back up this result. During the past 10-20 years several research groups have devoted themselves to detailed study of physics teaching and learning.

Methodology:

- Lots of oral exams.
- Determine right and *common wrong* answers (*mis*conceptions) to physics questions.
- Construct a multiple-choice test where the *wrong* answers are commonly believed misconceptions.
- Give the test to hundreds or thousands of students.

Hake (1998) used a test like I've described, the Force Concept Inventory (FCI), to survey the learning gains of 6,000 students in 62 physics classes in a number of institutions. Since students start with different levels of knowledge, results are reported as normalized learning gains. "Normalized gain" is the fraction of possible improvement a student achieves; <g> = 1.00 means he or she learned everything that was taught.

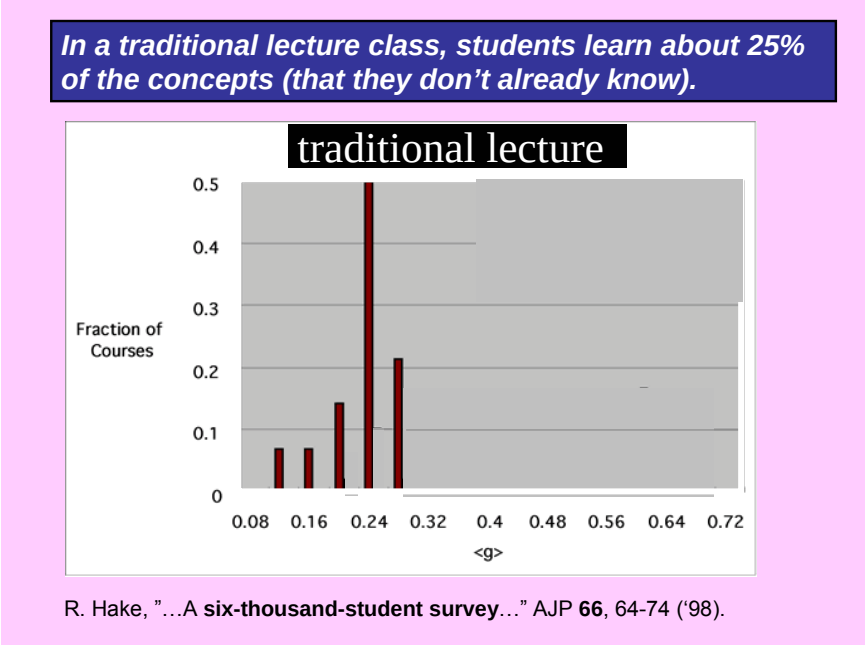

Figure 3.

As can be seen in Figure 3, it is typical for a class to learn on the average only around 25% of what is taught in lectures. Lest you think that your astronomy class is different from what is found in physics, Figure 4, from Lightman and Sadler (1993) shows that **astronomy instructors greatly overestimate how much their students will learn.**

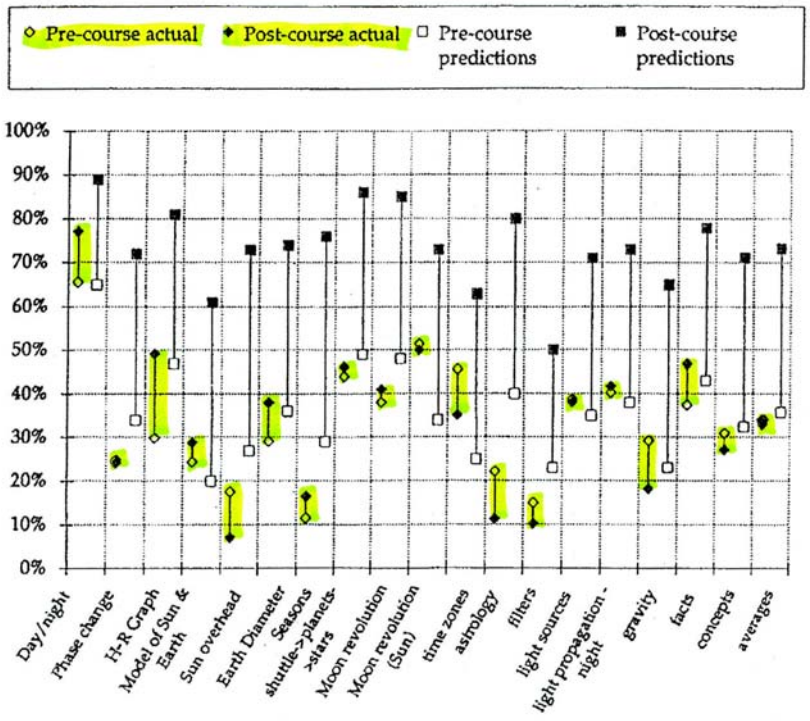

Figure 4. Comparison of instructor predications to actual student gains.

The conclusion is:

> ***Teaching by telling***
> ***is surprisingly ineffective* - if you want students to master concepts.**

II. How to do better, using clickers.

Students' minds must be active to learn. Clickers and "peer discussion" of conceptual questions force students to talk and reason during class. Here's an example. Place a prism in a beam of light and make a spectrum.

Sample *conceptual* question: What happens to the spectrum in the front of the room if I put a **red filter** into the beam?

a. Blue gets through, the other colors disappear
b. Red gets through, the other colors disappear
c. All the colors turn red
d. It depends on which side of the prism I put the red filter.

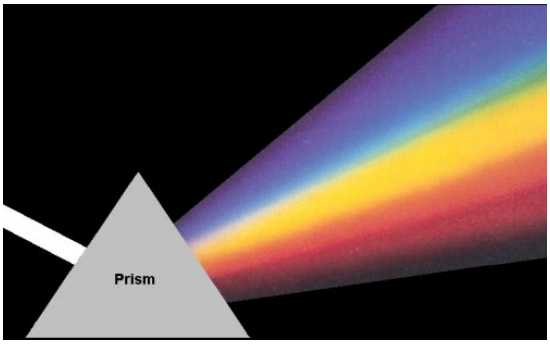

Figure 5.

Every time I give this question significant numbers of students choose *each* of the answers.

Since you are astronomers, and know the answer to the previous question, here is one that will be harder for you. Consult with people on both sides of you before answering.

How many liters of Scotch Whiskey are stored in warehouses in Scotland?

Hints: 1 liter = 1 bottle.
Scotch is aged 12 years before being sold.
If its not from Scotland, it's not Scotch.

A. 300,000
B. 3 million
C. 30 million
D. 300 million
E. 3 billion

The correct answer is "E," but the important point is how you and the class behaved while answering. Everyone was talking excitedly at once. This is the power of peer instruction. It is like the opening reception at this ASP meeting: everyone was talking at once, and enthusiastic. As Mazur (1997) describes, when students instruct each other in a peer mode, they more often find the correct answer than does an individual student, *and* they remember more at exam time. The clicker is used only as a tool to collect the answers. It is the student to student discussion that is important.

There are many uses that clickers may be put to:

- Measure what students know before you start to teach them
- Measure student attitudes
- Find out if they've done assigned reading
- Get students to confront common misconceptions
- Test student understanding
- **Increase student's retention of what you teach**
- **Facilitate discussion and peer teaching**
- **Transform the way you do any demonstrations** (Have students ***predict*** the outcome before you do any demonstration!)
- Increase class attendance
- **Improve student attitudes**

The uses outlined in **boldface** are the ones whose impact has been the strongest in classes I have taught.

Clickers are not the only way to get students to be more active, but **they are one of the easiest to implement.** Unlike tutorials or other lab-type activities – which can be very powerful – clickers can be introduced easily into any classroom. With radio clickers, such as the iClicker model we are using, no wiring is required and the instructor simply carries a small receiver that plugs into any laptop computer.

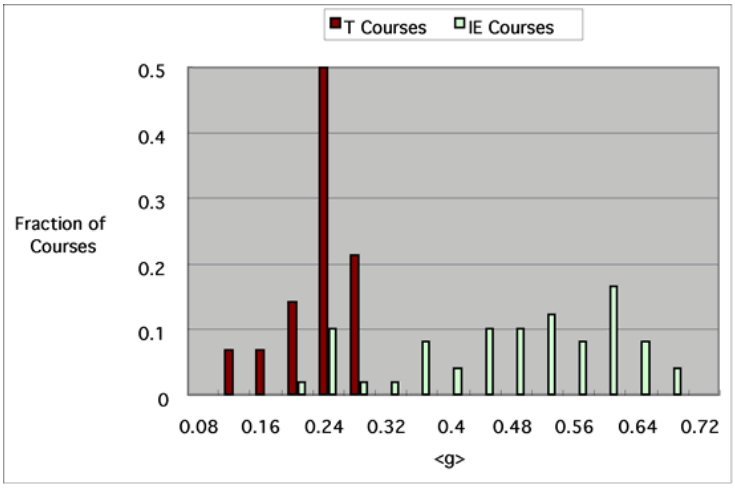

Figure 5. Traditional lecture courses compared to interactive education courses.

The difference that more active instruction makes can be seen by comparing Figures 3 and 5. The largest leaning gains are found in the most active classes, that use workshops or tutorials, but **classes that consistently use clickers and conceptual questions are found in the middle histogram bars of Figure 5.**

Not only do students learn more, but they like using clickers. At the University of Colorado attendance in large science classes that use clickers is around 15% higher than in non-clicker classes.

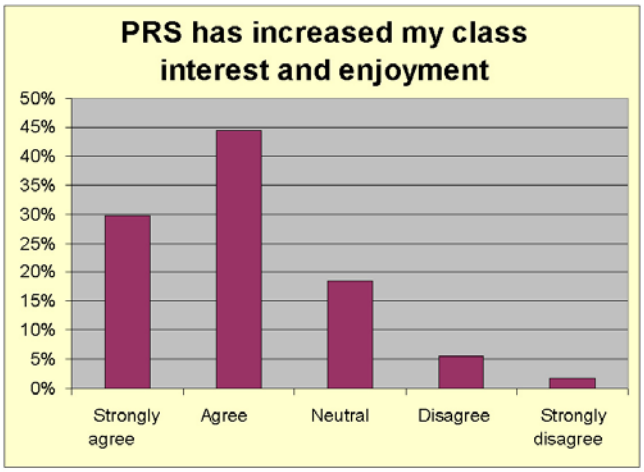

Figure 6. Results from a 1,000 student survey of opinions concerning clicker use.

III. Keys to success using clickers, and common problems to avoid.

Like any technology, even something as simple as clickers can be misused. Keys to success include:

Keys to success

1. You **must must must** explain why you are using them! Explain to students that they will learn more when debating and discussing with peers. "If you can't explain something, you don't really know it." Discuss what it means to learn science.
2. Practice *before* using clickers with students
3. Have your own goals clearly in mind.

4. If student participation is a goal, give partial credit for wrong answers. I give one point for any answer, and two points for the correct answer. Everyone participates and this scheme works great for me. Or try the Cuesta College scheme – give a bonus if ≥ 80% of the whole class gets correct answer.
5. Start with a few clicker questions per class and increase when comfortable
6. Questions must relate to the heart of your course
7. Clicker questions must relate to exam questions
8. The level must not be too simple or complex. 30% - 70% correct <u>before</u> peer discussion is ideal.

Clicker use means more work for students than just taking notes, and you should acknowledge this.

> It means they have to talk to the person next to them.
> Who they may think is an idiot.
>
> Without explanation why they must explain and debate
> with others, students may protest.

This is an actual student quote: "I expected you to teach me, I didn't expect to have to *learn!"*

You must explain why you are using clickers, or students will not be happy!

Problems to avoid

Registration errors can be a real pain. Check as early in the term as possible that every student is getting credit for their clicker answers. If they have not registered their *correct* clicker ID to their student ID they will not be getting credit.

Give students credit for using clickers. According to research at the University of Colorado, where 12,000 clickers are in use as of 2007, students *want* credit for using clickers. So make clicker use 5 or 10% of their grade.

When students are forced to buy more than one clicker they *hate* it! If more than one department at your university is using clickers, it is important to standardize on one brand. After considerable study the University of Colorado adopted iClicker as a robust and simple to use clicker brand.

Students who forget their clicker often panic. Plan to drop 6-10 lowest clicker scores and you will not have to deal with as much student pleading.

Discuss plagiarism with students, and explain that using or copying someone else's clicker answers in similar to copying their test or quiz.

How to get good clicker questions?

Student learning and enthusiasm is highly influenced by how good your questions are, and good conceptual questions are difficult to create. Once you have questions that work well it is useful to share them. As of fall 2007, the AAS office is considering hosting a compendium of clicker questions, submitted by AAS members or nonmembers, and available to all. The infrastructure to support this is already available using the COMPADRE data base found on the AAS website (www.aas.org/education/aasprojects.php).

The *Peer Instruction* manual by Green (2003) contains some useful questions, as do the materials furnished with some astronomy texts. Questions that address conceptual understanding and not just factual recall are the most useful ones.

Otherwise, one can use the methods of physics education research to produce good questions, though this takes more time:

- Interview some students
- Ask open-ended, conceptual questions
- Determine common wrong answers as well as right
- Use right and wrong answers to form good clicker questions.

Further Information

The topics of this presentation and others are discussed further in, "Clickers in the Astronomy Classroom" (Duncan, 2006).

References

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