i>clicker Pedagogy Case Study

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COURSE OVERVIEW

Course Title/Subject: Astronomy I.

Typical Enrollment/Student Information: ~200 students per quarter. This introductory astronomy course is taken primarily by students whose majors are not in the sciences.

Course Structure: There are three 50-minute lectures each week, and the clickers are used during every lecture. There are also weekly discussion sections led by graduate teaching assistants. Each section includes a cooperative learning session in which the students work in groups to solve a problem related to their weekly homework. The students submit their homework in written form.

In addition to the homework, there are 2 midterm exams and a final exam; all of these are multiple-choice exams.

Course/Student Challenges: The greatest challenge in teaching an introductory astronomy course is trying to impart conceptual understanding. This is particularly difficult because almost all astronomy students are plagued with a great number of deeply rooted misconceptions about how the physical world works and about the nature of objects in the heavens. A successful course is one that helps students replace these "common-sense" misconceptions with an accurate understanding.

Course Grading Policy: The final exam is worth 50% of the total points for the course; the midterm exams, 20%; the online homework and reading quizzes, 20%; discussion section participation, 5%; and in-lecture participation using the clickers, 5%.

MOTIVATION FOR USING i>clickers

There are a number of reasons I use i>clickers in the classroom:

- **To assess students' conceptual understanding of textbook readings and lecture content.**
- **To assess students' ability to apply important concepts.**
- **To obtain these assessments immediately.**
- **To encourage participation, discussion, and, in turn, further learning.**
- **To enable students to predict results of in-class demonstrations.**

IMPLEMENTATION

Obtaining/Registering i>clickers: Students purchase their clickers at our university bookstore as part of a package that includes the textbook. Rather than shrink-wrapping the clickers with the book, the publisher provides a bundle that includes the book and a mail-in rebate coupon for the clicker. Because 5% of the course grade is based on in-lecture participation using the clickers, students are required to purchase them. I require my students to register their clickers online using the i>clicker website.

Taking Responsibility: Students must bring their clickers to every lecture, including the first one. Before the term begins, I send my students an e-mail message to inform them of this responsibility.

Classroom Technology: In addition to i>clickers, I use a course management system (Sakai), an extensive website with all course information, and a commercial online homework system. In the lecture itself, I use PowerPoint augmented by video and animations as appropriate for the particular subject matter under discussion. I also use PowerPoint to display clicker questions in lectures.

i>clicker Grading Policy: As previously mentioned, in-lecture participation using clickers accounts for 5% of a student's grade. I emphasize that the clicker part of the course grade is based on *participation* only. I want students to answer each question to the best of their understanding, so that I get a sense of what they are thinking—whether or not their logic is correct. Thus, a student gets credit no matter what answer he or she gives. I do allow students to miss 3 lectures without penalty, which assuages those students who occasionally forget to bring their clickers or are tardy about registering them.

Daily Use/Questions Asked: To help my students, I use clickers in the lecture sections of my astronomy course. At various times during each lecture, I pose a multiple-choice clicker question that's intended to probe their conceptual understanding of the subject that I've just discussed. I encourage students to consult with their neighbors to reach a consensus about the answer. In this fashion, a large, impersonal lecture hall becomes an intimate discussion section, the students learn actively from each other, and they stay awake! I also get direct feedback about whether or not they truly understand the subject.

I generally pose 2–3 clicker questions per lecture, and I use these questions in 3 ways:

> **(1) To test students' understanding of their reading.** These questions probe students' conceptual understanding of a topic after reading about it in the textbook but before I discuss it in lecture. As an example, here is a question I pose after they have read the chapter about telescopes:
>
> *The primary purpose of building larger optical telescopes on the Earth's surface is to:*
>
> *A. increase the light-gathering power.*
> *B. increase the magnification.*

C. improve the resolution.
D. allow a wider range of wavelengths to be viewed.
E. see through the Earth's atmosphere.

Once students' responses identify how well they have grasped the assigned reading, I can tailor the lecture accordingly.

(2) To test students' ability to apply concepts. I pose these questions after presenting a topic in lecture to see whether students can apply it to a new situation. For example, after presenting the relationship among a star's luminosity, distance, and apparent brightness, I pose this question:

Two stars have the same luminosity. As seen from Earth, star #1 appears four times brighter than star #2. If star #1 is 20 pc away, star #2 is:

A. 5 pc away.
B. 10 pc away.
C. 40 pc away.
D. 80 pc away.
E. 160 pc away.

(3) To let students predict the results of in-class physics demonstrations. These questions test students' understanding of the physical principles that underlie the demonstrations. For instance, before discussing magnetic forces on moving charged particles (but after students are to have read about this topic), I pose the following question:

Electrons in a beam are traveling horizontally in the direction from north to south. You place a magnet directly above the beam, oriented so that the magnet's north pole is at the top and its south pole is at the bottom. How will the electron beam deflect?

A. Upward.
B. Downward.
C. Toward the west.
D. Toward the east.
E. The beam will not deflect.

Once the students submit their answers, I do the experiment in class to demonstrate what actually happens.

With any of these question types, I follow the same sequence:

(i) I pose the question and allow the students to submit their responses (I typically allow 2 minutes for this). I encourage the students to talk with their neighbors to see if they can reach a consensus about the correct answer. The students are not shy about doing this, and for 2 minutes, the large lecture hall is transformed into a beehive of discussion about astronomy and physics.

(ii) I display the histogram of student responses and the grid that shows how individual students responded. I then select 2 or 3 of the responses, including the most popular, as well as the correct one (which is not always one of the most popular).

(iii) For each of the responses that I select, I call on a student who gave that response to explain and justify why he or she did so. (I bring to lecture a printed list of which transmitter ID goes with which student, so I can call on students by name.) This reveals the thought processes that the students used to answer the question. I find that students are not shy about speaking in lecture (it probably helps that each student called on for an explanation gets rewarded with a piece of candy).

(iv) Only after I've heard students justify each of the selected responses do I reveal the correct answer. (If the question required students to predict the results of a lecture demonstration, this is the point at which I actually do the demonstration.) When I do this, I'm careful to dignify the explanations given by those students who selected a wrong answer. For example, I would turn to the student who explained why he selected answer D to the second question presented earlier and say, *"You were correct in saying that the dimmer star is farther away, but remember that the brightness depends on the square of the distance—which is why the answer is C."* The experience is a memorable one for students, and they truly seem to internalize what they learn from the clicker question.

RESULTS

Successes

Fostered More-Effective Classes. The use of i>clickers in my lectures has revolutionized the way that I teach, as well as the way that my students learn. It has enabled me to discover conceptual sticking points of which I had previously been unaware.

Inspired Introspection. i>clickers have allowed my students to examine their modes of thinking about astronomy and to identify their misconceptions about the subject.

Created Memorable Demonstrations. Using i>clickers has also made the lecture demonstrations more memorable and meaningful by forcing students to think about these demonstrations before seeing them in action.

Increased Participation. Most importantly, it has transformed my students from passive spectators in the lecture hall to active participants in their own learning.

Increased Attendance. As a side benefit, making the use of clickers a required part of the class has increased attendance in the lectures.

Challenges

The use of clickers is not a panacea. An important goal of my astronomy course is for students to learn how to solve quantitative problems, and the use of clickers alone cannot provide students with this skill. However, conceptual understanding is a necessary foundation for problem-solving ability, and clicker questions can help provide this foundation. The discussion sections, including their cooperative learning sessions, provide students with an opportunity to build on this foundation.

Clicker questions also take up lecture time that traditionally would have been used to address more material. However, I prefer that students learn fundamental principles in more depth (which the use of clicker questions helps to make possible) rather than seeing a large number of topics discussed in a superficial way. Once students grasp these fundamental principles, they can more easily apply them to secondary topics.

CONCLUSION

I will certainly continue to use i>clickers in Astronomy I and have expanded their use to my introductory physics courses, as well. I simply cannot imagine returning to the old style of teaching without clickers.

Recommendations for Optimal Results

The use of clickers does require a change in the instructor's mindset from pure lecturing to a much more interactive style of teaching. Faculty contemplating the use of clickers should be prepared to make this change.

They should also plan to spend a little time before the course begins becoming intimately familiar with the clicker software and hardware. The i>clicker system is by far the easiest and most user-friendly clicker system there is, but it still needs to be learned. Fortunately, i>clicker provides excellent tutelage in the use of its system, and I would encourage every faculty member planning to use i>clicker to take advantage of this. The reward for the brief amount of time spent in this training will be a smooth-running class in which students take an active part in their education.