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Why Use a Classroom Response System?

Key Points

- Limitations of traditional lectures
- Engaging students in peer discussions
- Learning gains you can expect
- Attitude gains you can expect
- Instructors' opinions about using clickers

Limitations of Traditional Lectures

No matter how good a teacher you are, if you teach solely by lecture, you will lose the attention of many of your students just minutes or tens of minutes after your lecture has begun. An interactive system such as clickers can maintain a much higher level of student involvement.

Teachers strive to be clear and understandable, to motivate and inspire their students. We do so at least in part because we expect that it will help our students learn. Certainly a dull, unclear presentation will discourage students and prevent their learning. But it is also true that *the lecture format itself* imposes limitations on one's ability to teach. Data show very clearly that the success of even an exemplary lecture is limited by the way students learn.

One basic limitation is the attention span of passive learners. Studies indicate that the full attention of students falls off remarkably quickly—in just minutes. IBM performed a study in which the students had strong motivation to learn: All were newly appointed managers, and the classes, taught at IBM headquarters, were an essential part of their jobs. Five classes of 20 students

each were studied. Because IBM considered it important that all these students did well, the company carefully studied many aspects of the classes. Observers found that at the beginning of each class, most students exhibited attentive behavior, but that attention diminished rapidly within 20 minutes. Observers watched each student and marked whether he or she was attentive, which formed an index that was equal to 100 when every student was paying attention, 50 when half were, and so on. The average number of students paying attention during a standard lecture was 47. When the lecture was changed to a style in which the teacher actively engaged students with questions, the attention average rose to 68. The observers also noted that in a typical class, 10–20% of the students dominated the discussion. The remaining 80–90% contributed only occasionally. In an effort to improve students' participation, IBM built a prototype interactive classroom in which a student response system allowed every student to respond to teachers' questions. A computer system immediately displayed student responses in graphical form. When the same criteria used to measure students' attentiveness was applied to the classroom with student response units, the attentiveness index was found to be 83. Testing showed that the students in the class with the response system scored significantly higher than the students in the traditional classroom. Students were asked to rate how much they liked the response system, on a scale from 1 to 7, and the average was 6.6. More detail may be found in Horowitz (1988).

IBM conducted the tests described above in 1984–85. Twenty years later, technology has advanced greatly and classroom response systems are available at a fraction of the cost of the IBM prototype. But the way students learn has not changed, and studies in universities have documented that the “fade” in attention during a lecture is a universal phenomenon. Teachers can deal with this by using classroom response systems to “fight the fade” (cf. Pollock, 2004).

For more evidence that traditional lectures fail to produce as much long-lasting learning as we would like, consider the following example from Nobel Laureate Carl Weiman (2004). Weiman is a strong advocate of the use of clickers during lectures and demonstrations. He reports the following example of trying to teach how a violin works—that the body of a violin is essential for amplifying the sound of the strings. Most students have the misconception (or preconception) that the strings make all the sound.

Explaining about sound and how a violin works. I show class a violin 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. Point inside violin to show how there is a sound post so strings can move the



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bridge and 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 a. mostly strings, b. mostly by the wood in the violin back, c. both equally, d. none of the above.

Your multiple-choice question is: What fraction of students do you think got the correct answer?

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

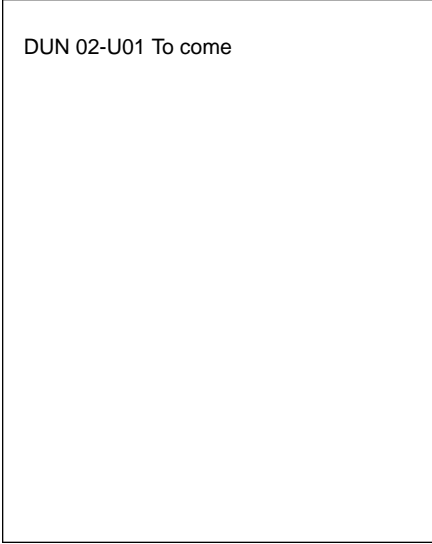
Test your own expectations and choose a, b, c, d, or e. Remember that the question was asked just 15 minutes later, and in the same lecture that the material was taught.

The result was “b.” Only 10% of students gave the correct answer. This is a dramatic example of what is now widely known: An explanation, even a good, clear one (in this case with a demonstration!) often fails to reach students who have misconceptions. Something more active is needed.

Engaging Students in Peer Discussions


Clickers are useful in fighting the “fade” of attention that occurs during lectures. Engaging students can mean more than just holding their attention, however. Clickers are ideally suited to bring about more student involvement through peer instruction or peer discussion. In this approach, teachers use clickers to survey student answers to a thought-provoking conceptual question. If the classroom response system indicates a diversity of opinion, teachers give students several minutes to discuss the question with their neighbors in the lecture hall. It has long been known that teaching someone else helps to understand an idea, and compelling evidence presented in Chapter 6 shows that this relatively easy-to-implement technique can significantly increase student learning. Appendix 2 presents evidence that peer instruction can also greatly raise interest in and enjoyment of science among nonscience majors.

As the photographs show, lecturing has not changed much in two millennia. With the advent of classroom response systems, however, that need not remain the case.



DUN 02-U01 To come

Ancient lecture hall



DUN 02-U02 To come

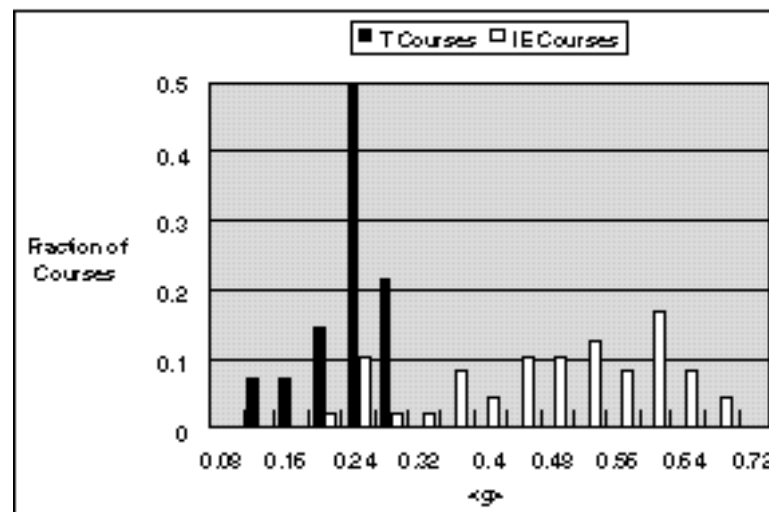
Modern lecture hall

Learning Gains You Can Expect

A large body of research shows that classroom methods that actively involve students result in substantially greater learning than pure lecturing does. Active learning methods may involve working in studio settings or on projects (e.g., McDermott et al., 2002; Laws, 2004), interactive lecture demonstrations (Sokoloff & Thornton, 1996), or peer discussions during lectures about conceptual questions—questions that probe the meaning of a subject, not just the ability to calculate. (See Appendix 3.) Clickers work particularly well with peer discussions, as described in Chapter 6.

Some of the clearest documentation of the success of more active teaching approaches can be found in physics, as the field of physics education research has been active for many years. An important aspect of that field is the existence of several testing instruments such as the *Force Concept Inventory* (Hestenes et al., 1992), which, even though they are multiple-choice tests, are generally agreed to be good probes of students' conceptual understanding. Such instruments are generally developed through research, often on the basis of interviews with many students, that identifies students' most common misconceptions. The misconceptions are then used to create the “distractors,” or wrong answers, on the tests. Such tests work remarkably well in identifying whether students have learned important concepts, and the tests can be given to large numbers of students.

Hake (1998) used the Force Concept Inventory (FCI) to survey the learning gains of 6,000 students in 62 physics classes at a number of learning institutions. Since students often start with different levels of knowledge, results are reported as normalized learning gains. A “normalized gain” is the fraction of possible improvement a student achieves. For example, a student who scores 40% correct on the FCI the first week of a class could possibly improve 60% during the term. If the student achieves 70% when retaking the FCI at the end of the term, the normalized gain, $\langle g \rangle$, is $30\% \text{ improvement} / 60\% \text{ possible improvement} = 0.5$. A key result from Hake’s paper is shown here, where T marks the courses taught with traditional lectures and IE marks the courses taught with interactive educational methods.



This graph shows that even the best traditional lecture courses produced only about a quarter of the possible learning gains. Furthermore, the difference between excellent lecturers and poor ones was surprisingly small. Even the worst of the more interactive classes did better than most of the lecture classes. Hake also found that the worst interactive results all came from classes where the instructor was not well-trained in interactive methods or where there were serious equipment problems. These results certainly encourage clicker use and argue strongly for introducing at least some active methods into lecture classes.

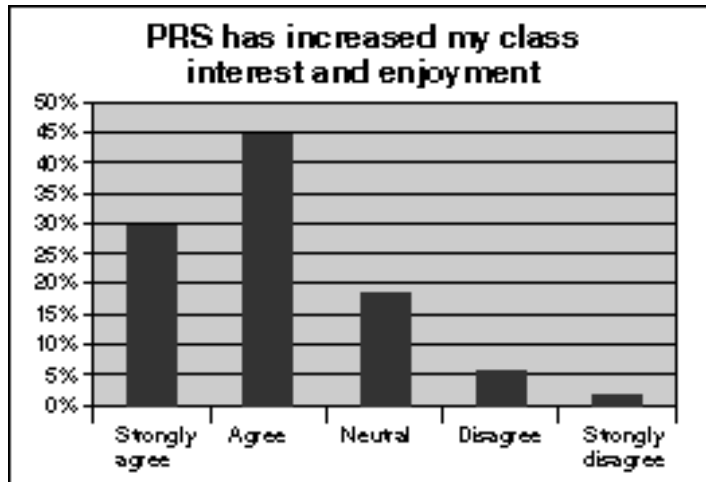
Just using clickers in class does not mean that your class will immediately achieve the results of an interactive education course. But clickers are especially well adapted for use in peer instruction, an interactive technique that is easy to start with just a small number of peer discussion questions, as

described in Chapters 6 and 7. However, the best peer instruction carefully integrates into the overall curriculum the conceptual questions students are asked to discuss and answer. Furthermore, as mentioned in Appendix 3, midterm and final exams are designed to test conceptual knowledge. Our advice is to start with a limited number of clicker questions, evaluate how happy *you* are with the results, and proceed from there.

Attitude Gains You Can Expect

Although the main goal of instructors is for students to learn, student attitudes toward your subject should not be ignored. If we truly believe that learning is a lifelong process, we will be happier with a student who leaves a course thinking the subject matter was interesting and involving rather than one who leaves thinking it was irrelevant and boring. Appendix 2 presents a compendium of the comments of students in a large lecture course when peer discussion was introduced. Because the course was taught for 4 years before clickers were available, the comments were engendered by peer instruction, not clicker use. It is clear that these nonscience majors found peer discussion involving and interesting, and equally clear that previously they had not felt that way about science classes.

At the University of Massachusetts, students were directly asked how clicker use affected their class enjoyment. Typical results for a class of several hundred follow.



Instructors' Opinions about Using Clickers

Most instructors are enthusiastic about using clickers and feel that some practice makes the experience better. The following typical verbatim comments are from the survey of Trees and Jackson (2003):

“Better attendance, less sleeping in class, more background noise because they get in the habit of talking in class during clicker questions.”

“I love what clickers have done for my classroom. The main benefits are (1) increased attendance; (2) active participation; (3) better preparation for class.”

“Compared to . . . conventional lectures it's a world of difference—more engagement, better feedback in both directions, makes large classes feel much smaller.”

“Students did seem really interested in seeing how the questions were answered by their classmates. They would react when they saw the graph.”