“Clicker” Cases: Introducing Case Study Teaching Into Large Classrooms

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Large numbers of students do not like science (Seymour and Hewitt 1997; Kardash and Wallace 2001). Surely, this will come as no surprise. Most U.S. students receive their first college science training in large lecture classes in fixed-seat amphitheaters. A high proportion of these students withdraws or fails. Tobias (1990) found that science majors have a high tolerance for the cut-and-dried approach epitomized by most lecture styles—facts, facts, and more facts—whereas nonscience students are often bored to death, even though they may receive high grades. We know that the impersonal nature of the lecture, its lack of real-world application, and its prioritization of facts and memorization over critical analysis, synthesis, and discussion, deter many bright students from careers in science.

Can we do anything to alter this state of affairs? Yes, if the following example is any indication. In his introductory astronomy class at the University of Colorado, Duncan (2005) reported that at the beginning of his course only 10–15% of students indicated that they liked science. He was able to modify the perceptions of most of them by strikingly reducing the traditional lecture component of the course and developing interactive exercises, demonstrations, and peer instruction. At the end of the course, Duncan again polled his students anonymously, and 80–90% had changed their views to a more positive opinion of science.

Reinforcing this observation that active learning strategies are important even in large classrooms, Hake (1998) reported the results of a study on 6,000 students in 62 introductory physics courses at different schools. Courses with active learning strategies were far superior in producing learning gains than traditional lectures. Indeed, the worst of the interactive courses did better than most of the lecture courses. Furthermore, there was little difference among lecturers, regardless of their perceived skill.

Clearly, case study teaching, with its emphasis on active learning and problem solving within complex and real-world contexts, has something to offer here. But we have to face facts. In spite of its demonstrated effectiveness in small classes and tutorials, the use of case studies in large classes is severely hampered. Discussion in such settings is often negligible. Typical question and answer interactions in large classrooms are often dominated by a small minority of students, and it is difficult and often impossible to hear a student speak in a large auditorium. Even discussions among student groups, one of the key techniques of many forms of case teaching including, for example, Problem-Based Learning, is restricted because of the fixed-seat amphitheaters that we use for large classes.

Large lecture classes are a fact of life at universities, especially in the introductory science courses. They are clearly cost effective. A single instructor can present material to hundreds of students at a time. Once lectures are prepared, only modest annual revisions are typically required. Multiple-choice exams (the normal testing procedure) are easy to concoct and readily available from textbook companies, and they are easy to grade via electronic scoring services available at universities.

But there are many well-documented disadvantages of large lecture classes, including problems with attendance, discipline, learning, and the general alienation of students (Tobias 1990; Pinet 1995; DeCaprariis 1997; McConnell, Steer, and Owens 2003; Greer and Heaney 2004). Attendance in the normal lecture class frequently dips below 50%, and the percentage of students that drop introductory science courses or receive “D” or “F” grades is often 40% (Hatch, Jensen, and Moore 2005).

Attempts to offset the problems of lectures in large classes include using Think/Pair/Share, Just-In-Time Teaching, Peer Instruction, ConcepTests, computer-based instruction, recitation sections, case study teaching in lab sections, and, more recently, student response systems (Mazur 1997; Hatch, Jensen, and Moore 2005; Smith et al. 2005; Twigg 2000). Some of these approaches show significant changes in student attitudes and learning gains. The critical feature in these positive experiences is that the instructors are using feedback systems that transform the classroom into an interactive experience. Mazur, teaching physics at Harvard, argues that his 10-year experience using Peer Instruction does not depend on a particular feedback method (Crouch and Mazur 2001). Interactive feedback is the key. It is the feedback pedagogy that is the driving force for success, not the particular technological method involved (Byrd, Coleman, and Werneth 2004; Draper, Cargill, and Cutts 2002; Judson and Sawada 2002). Nonetheless, today we have a new feedback system—"clickers." They are practical and economical. And their use allows us to effectively introduce case study teaching into large classrooms.

Clickers in the Classroom

Student response systems and audience response keyboards, or "clickers," as they are often called, have been commercially available for the past 15 years, although they were preceded by fixed electronic response systems (Judson and Sawada 2002). Made famous by their use in the TV quiz show *Who Wants to Be a Millionaire?*, clickers are rapidly infiltrating higher education classrooms. They provide instant feedback to students and faculty regardless of the size of the class, and have a clear value in socialization, making impersonal classes more intimate. The technology also seems to resonate with students' fascination with interactive media.

For years, some instructors have attempted to garner responses to questions by asking students to hold up their hands, say in ConcepTests, as used in Peer Instruction (Mazur 1997). Unfortunately, students regularly alter their votes in front of their peers. This problem is avoided when clickers are used, as they are perceived to be anonymous, making it possible to collect more accurate data in the classroom. If truly anonymous results are desired, the instructor can ask students to switch devices with their neighbor.

Clickers are similar to a TV or stereo remote control, with numbered buttons that students can push to register their votes. Typically students respond to questions framed in a multiple-choice format. Transmitted by either infrared or radio frequency signal, a receiver picks up the answers and then relays them to a classroom computer. The results can be immediately displayed as a chart on the computer screen and projected for the class. The data can be stored and retrieved later, either as an anonymous record or by identification with a personal ID (Greer and Heaney 2004).

The appropriate and successful use of clicker technology is associated with a variety of educational and psychological theories. Its use has been linked to increased attention (Jackson and Trees 2003; Horowitz 1988), which facilitates long-term memory storage. The recent success of clickers has been attributed to a shift from usage grounded in behavioral learning theories to that which encourages individual and social constructivist learning environments (Crouch and Mazur 2001; Draper, Cargill, and Cutts 2002; Dufresne et al. 1996; Judson and Sawada 2002; Roschelle, Penuel, and Abrahamson 2004). Research on various forms of instructional feedback, all of which can be provided by clicker systems, has indicated direct relationships between feedback and improved student learning (Guthrie and Carlin 2004). It has also been argued that clicker use improves motivation (Crouch and Mazur 2001), which may lead to cognitive persistence (Dufresne et al. 1996) and increased mastery goal setting (Roschelle, Penuel, and Abrahamson 2004).

In his book *Clickers in the Classroom: How to Enhance Science Teaching Using Classroom Response Systems*, Duncan (2005) lists 11 ways faculty use clickers: to measure what students know prior to instruction (i.e., preassessment); to measure student attitudes; to find out if students have done the reading; to get students to confront misconceptions; to transform the way they do demonstrations; to increase students' retention of the material they have been taught; to test students' understanding; to make some kinds of assessment easier; to facilitate testing of conceptual material; to facilitate discussion and peer instruction; and to increase class attendance.

Fundamentally, clickers are used in two different ways: either by individuals or by small groups of students. When individuals use them, either the school loans them out or instructors require that students purchase them from the bookstore. If being used by a group, they are handed out each class period and retrieved at the end of the session, as done at the University of Georgia (Brickman 2005).

There are few formal assessments on the use of student response systems because they are new on the educational scene. Nonetheless, some results are available (Judson and Sawada 2002; Greer and Heaney 2004; Hatch, Jensen, and Moore 2005; Duncan 2005), from which we have learned the following:

- Student enthusiasm for clickers is high. Whether it is their novelty or actual educational value is not clear. Nonetheless, students, particularly in large science classes, report they enjoy using them and believe they help them understand the material and prepare for exams.
- Student attendance is strikingly improved, changing from below 50% in the lecture method to over 80% when clickers are used. This observation is confounded because many instructors give points for attendance, which can be more closely monitored with clickers. Nonetheless, because grades are strongly correlated with attendance, this effect must be applauded.
- Student learning appears improved (although this may be because of their novelty, as in the well-known Hawthorne effect).
- Faculty enthusiasm is high, at least for those individuals willing to experiment.
- Student apathy is much less evident.

The disadvantages are several:

- There is a steep learning curve for faculty as they negotiate the “ins and outs” of the clicker software. Like any classroom technique, clickers can be used well or poorly. In a study at the University of Massachusetts, students’ ratings of professors improved as professors became more experienced (Duncan 2005). So any project using clicker technology must have a training period associated with it.
- Clickers are particularly effective for eliciting responses to questions at the lower level of Bloom’s (1956) taxonomy, where questions involving facts are involved. With care, critical-thinking questions can be devised that focus on synthesis, evaluation, and analysis. However, designing effective clicker questions at the highest levels of Bloom’s taxonomy requires significant creativity and time.
- The technology can be problematic, especially for large classes and when using infrared systems; these difficulties are largely eliminated with radio frequency.
- Cheating (one student bringing a friend’s clicker to class) can occur and must be strongly discouraged and penalized.
- Rules and strategies must be established for lost, forgotten, or inoperable clickers; usually dropping the clicker scores for three to four classes out of the total will take care of the problem.
- The cost can be a deterrent as can be the storage of clickers. These potential difficulties can be minimized if students buy their clickers as part of the textbook package and are made responsible for them.
- Schools are scrambling to standardize their clicker systems so that students do not have to purchase multiple clickers for different classes. Five major clicker companies are competing for their share of the business: Turning- Point, InterWrite Products-PRS, Classroom Performance System (CPS), Hyper-Interactive Teaching Technology (H-ITT), and Quizdom Student Response System.

The disadvantages of clickers are minor when compared to their advantages, hence their rapid assimilation into the nation's classrooms. In the near future, electronic response systems will rapidly improve to allow students to do more than answer multiple-choice questions; ideally, they will permit a student in the middle of an amphitheater to speak or transmit their version of a graph or diagram. There are already prototype systems that use cell phones and others that use laptop and tablet PCs and PDAs as student input devices. We can expect these to become integrated with learning management and course management software (such as Blackboard or ANGEL) as we push the boundaries of classroom communication systems (Beatty 2004). Thus, clickers are merely a first step to using interactive techniques with case study teaching in large classes.

Clicker Cases

The ongoing evolution of personal response systems has made it feasible to marry interactive and case study teaching methods, producing what we call "clicker cases."

I have found one method of case teaching in particular to be ideally suited for use with clickers. Called the Interrupted Case Method (Herreid 2005), the case is delivered in parts, or stages. After each stage, students are asked to respond to questions posed by the professor. The method mimics what real scientists experience as they work their way through a problem—they identify key questions, develop hypotheses, design ways to test them, gather data, and draw conclusions, in an iterative process, refining their thinking about how to attack the problem as more information becomes available. Moreover, this method of teaching cases has been shown to be the most popular among science faculty (Yadav et al. 2006).

The Interrupted Case Method has proved successful in small classes, but is difficult to administer in large fixed-seat amphitheaters. However, Brickman (2005) has had significant success, even in classes of several hundred students, using permanent small groups and Team Learning (Michaelsen, Knight, and Fink 2004) with clickers. At the University at Buffalo, we have used the method with clickers with great success in a general biology class of 450 students.

The way that we have used it is simple: an instructor selects a topic, such as the HIV virus replication cycle. In class, the instructor takes students through a series of carefully developed scenarios drawn from students' texts and recent literature. At each stage, students are given information and asked to predict what might happen if such and such were done. As a hook into the problem, for example, the tragic story of tennis great Arthur Ashe, who contracted AIDS from a contaminated blood transfusion, is introduced. Also, some of the history and spread of the disease is presented.

With this as background, students are asked at what point scientists might attempt to interrupt the viral reproduction cycle. Students are shown a series of options and asked to vote using their clickers, with their choices displayed as a histogram on a PowerPoint slide to the whole class. They are told of one early attempt to control the disease using the drug AZT. Students are asked to predict what would happen if AZT were administered to a patient if the treatment worked, and shown a series of graphs following the number of virus particles in the blood over time. Before voting, they can consult with their neighbors. The instructor, using a microphone, asks a few students their thoughts. After students vote, the real results are shown. Then another experimental scenario is presented, which continues the story line in our understanding of HIV.

It is important to emphasize that this case method integrates lecture material, case scenario material, student discussion with their neighbors, clicker questions, clarification of the answers, more lecture, and data. And the cycle is repeated. The data we have collected indicate that attendance jumps dramatically (90%) and students write that they greatly value this approach over the traditional lecture. Performance on critical-thinking questions also improves and class grades rise. Using clicker cases promises to offset many of the criticisms that have been leveled at science teaching, especially in large enrollment science courses, as it engages students in real-world problems and challenges them to think every step of the way.

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