TEACHING WITH CLICKERS

Erping Zhu

What Do Students Appreciate Most about Clickers?

In a class of several hundred students, it is virtually impossible for each student to participate and interact with the professor. I like the Quizdom system because it allows each student to actively participate and thus gauge their comprehension.

I definitely pay more attention to the lecture when the interactive questions are being asked. There isn't pressure to raise your hand, because there is a confident anonymity about answering the questions. It's a good system.

They allow me to interact with the material and make sure that I understand the lecture. They force me to apply what I've learned, also ensuring that I will be better able to remember it in the future.

Using the clicker gives me a chance to think about what I'm actually writing down in my notes, rather than just having a collection of incomprehensible formulas scattered through my notes.

Using clickers encourages me go to class, encourages me to discuss concepts with students around me.

During the course of a clicker question, we would discuss the problem, which was sometimes how I learned the most about a topic.

I like answering questions with them. They really help because you can see that not everyone understands the material, so the professor will then go over the material again.

Student survey responses
(Zhu, Bierwert, & Bayer, 2006, 2007)

How Are Faculty Using Clickers in the Classroom?

Since the 1980s, the use of clickers has proliferated on college campuses. Faculty from various disciplines such as biology, chemistry, history, mathematics, political science, law and psychology have

Erping Zhu is Coordinator of Instructional Technology at the Center for Research on Learning and Teaching (CRLT) at the University of Michigan. She has a Ph.D. in Instructional Systems Technology.

introduced clicker systems into their classrooms. Faculty use clickers for various purposes depending on their course goals and learning objectives. The most common uses of clickers include the following:

Assessing students' prior knowledge and identifying misconceptions before introducing a new subject

Prior knowledge is necessary for learning but can be problematic if it is not accurate or sufficient. It is a good practice for faculty to assess students' prior knowledge of a subject and identify common misconceptions in order to find an appropriate entry point for introducing a new topic. By using clicker multiple-choice questions, faculty can quickly gauge students' knowledge level. For instance, in a Fall 2006 Chemistry class at U-M, the professor started each lecture with clicker questions asking students to identify new concepts or distinguish between various new concepts discussed in the assigned readings.

Checking students' understanding of new material

Clicker technology makes it easy for faculty to check students' mastery of lecture content. The immediate display of student responses enables faculty and students to see how well students understand the lecture. As a result, faculty can decide whether there is a need for further instruction or supplementary materials. By seeing peers' responses, students can gauge how well they are doing in relation to others in the class and determine which topics they need to review or bring to office hours.

Using Peer Instruction and other active learning strategies

Peer Instruction (Mazur, 1997) and Think-Pair-Share (Lyman, 1981) are cooperative learning strategies that faculty often use to probe students' understanding of lecture content and encourage them to discuss, debate, and defend

> **What Is a Clicker?**
> A clicker system consists of three components:
> 1) clickers: wireless handheld transmitters that resemble small, TV remote controls;
> 2) receiver: a transportable device that receives signals from the clickers; and
> 3) software: an application installed on the instructor's computer to record, display, and manage student responses and data.
>
> Although radio frequency transmission seems to have become the standard for now (Duncan, 2006), infrared transmission is also still in use. The design of clicker pads varies widely, and the different clicker systems –Classroom Performance System (CPS), Audience Response System, Qwizdom, TurningPoint, H-ITT, Classtalk – are incompatible.

their answers during lecture. The strategy entails posing a question to students, giving them time to think and discuss their responses with a partner, and then describing the results to the whole class.

Clicker technology makes the use of these strategies feasible and manageable, even for large classes. For example, the instructor will plan for each lecture several concept questions that focus more on the analysis and evaluation of information than simple recall, rote memorization, or calculation. Students are asked to share and discuss their responses with partners. Some faculty ask students to respond twice to difficult questions, once right after they read the question and then again after they talk to their partners. The faculty member then reviews and explains students' different responses, helping them clear up their misconceptions.

Research in physics (Crouch & Mazur, 2001) shows that students' cognitive gains from peer instruction are significant: students' scores on tests measuring conceptual understanding improved dramatically; their performance on traditional quantitative problems improved as well.

Starting class discussion on difficult topics

The anonymity of responses facilitated by the clicker technology allows faculty to initiate class discussion and debate on sensitive topics that might otherwise be difficult to explore. For example, questions on controversial issues in a political science course can sometimes be met with absolute silence (Abrahamson, 1999), but the use of clickers can help change classroom dynamics. Faculty can start the class lecture or discussion by posing controversial questions and offering "common-sense" multiple-choice responses. Students' responses, and their questions about their peers' responses, can provide an opening for class discussion. When students recognize their own opinions and co-direct a class discussion, they may feel a greater sense of ownership over the lecture and discussion. As a result, they will be more engaged in and responsible for their own learning. Also, instead of drawing conclusions from the most vocal students, the faculty member receives a far more accurate overview of opinions from the entire class. Most important, the anonymous feature of the clicker system ensures that viewpoints that might not otherwise be expressed during class discussion are given a voice.

Administering tests and quizzes during lecture

The relative ease of managing students' responses has made the clicker system a helpful device for testing and grading during lecture. Features such as automatic scoring and record-keeping for each student enable faculty to administer all sorts of tests and quizzes in large lecture halls. For example, in one physics class at U-M, students' responses to questions posed during lecture are scored. Students who answer the questions correctly earn points that count toward a small percentage of the course grade (allocating too many points to a clicker quiz can increase the likelihood of cheating). Moreover, with instant feedback from students, faculty can adjust the pace of a lecture and the amount of content presented, assist students in identifying their knowledge deficiency, help students re-evaluate their study strategies, and determine what additional resources they might need to provide.

Gathering feedback on teaching

With clicker technology, faculty can gather anonymous feedback on their own teaching by asking students to respond to questions regarding the lecture, class discussion, homework assignments, group activities, or the overall learning experience in the course. If used early in the term, faculty can make changes to the class that benefit students before the end of the term.

Recording class attendance and participation

Taking attendance in a large lecture course is usually daunting, if not impossible. But with a system that recognizes each student, it is feasible and convenient for faculty to take student attendance in a large lecture. For example, students' responses to questions asked at the beginning of the lecture often serve as a record of their attendance. The instructor can easily run reports on student responses and find out who is present or absent from the class.

Admittedly, faculty hold different views on student class attendance. Some firmly believe that being in class and listening to a lecture is an integral part of learning, making class attendance a must; others think it is not essential for learning and it can be left to the students to decide. Similarly, student opinions about mandatory class attendance vary. Some U-M students surveyed in 2006 and 2007 responded negatively when clickers were used only to check class attendance (Zhu, Bierwert, & Bayer).

There are many other creative ways clickers are being used in classrooms. Draper, Cargill, and Cutts (2002) list three: Students can use them to give anonymous feedback on their peers' class presentations by responding to a brief post-presentation survey. Faculty can create a sense of community and group awareness by clustering people's hobbies, habits, and preferences through student responses to anonymous surveys. Faculty may also use clickers for psychological experiments. Kam & Sommer (2006) note the use of clickers for campaign simulation and polling research, as well as the technology's ability to monitor and facilitate individual and group games. In summary, the only limitation on innovative applications of clickers is the creativity of the instructor.

What Are Student and Instructor Attitudes towards Using Clickers in the Classroom?

Over the past twenty years, studies examining the usefulness and weakness of clickers in various instructional settings have revealed both promise and problems. In Fall 2006 and Winter 2007, surveys were conducted of students taking Literature, Science, and the Arts (LS&A) classes that used clickers. The surveys asked students whether clickers were helpful for improving teaching and student learning. The findings were consistent with those from studies in institutions across the country, revealing both strengths and drawbacks of this technology.

Positive feedback

The research on student and faculty attitudes indicates that most students enjoy using clickers in class because it makes lecture more fun and interesting (Beekes, 2006; Conoley, Moore, Croom, & Flowers, 2006; Duncan, 2006; Stuart, Brown, & Draper, 2004). Students also welcome the use of clickers to check their prior knowledge or understanding of the content during lecture (Abrahamson, 1999; Cue, 1998; Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Shapiro, 1997). Students reported that they were able to improve their own understanding of the content and better understand the instructor's expectations (Tomorrow's professor, 2006). Clicker questions help

students learn because they are more likely to respond to questions and participate in the class discussion when clickers are used (Greer & Heaney, 2004; Hoffman & Goodwin, 2006). Clickers have also been shown to help facilitate and enhance learning (Conoley et al.; Uhari, Renko, & Soini, 2003).

Feedback from students at the University of Michigan about using clickers in teaching shows similar trends. Surveys of large LS&A classes that used clickers in the Fall 2006 and Winter 2007 semesters showed that most students (54%) liked using clickers in class. Over 55% of students thought more about the material during lecture when clicker questions were asked (Zhu et al., 2006, 2007). Similarly, most students (57%) either strongly agreed or agreed that clicker questions helped them clarify whether they comprehended the lecture material (Zhu et al., 2006). Furthermore, about half of the students surveyed either strongly agreed or agreed that the use of clickers forced them to come prepared for class by doing the assigned readings and also made them pay more attention in lecture (Zhu et al., 2006). While clicker use improved student class attendance in large lecture courses, over 68% of students strongly agreed or agreed that clickers are better used for getting them to interact and receive feedback on their understanding (Zhu et al., 2007).

Negative attitude

Amidst all the positive feedback, a few negative comments about clickers have been reported. One of the most common complaints is the additional cost of purchasing a clicker (Greer & Heaney, 2004; Zhu et al., 2006, 2007). For both students and faculty, encountering technical difficulties during class engenders some negative attitudes toward the use of clickers (Hall, Collier, Thomas, & Hilgers, 2005; Silliman & McWilliams, 2004; Zhu et al., 2006, 2007). In some cases, students disliked using clickers in class because they did not add much to the classroom experience and ruined the flow of a lecture (Knight & Wood, 2005; Zhu et al., 2006, 2007). In addition, U-M surveys showed that students do not like very basic clicker questions that only record their answers and take attendance. Inconsistent use of clickers and the absence of faculty feedback on student responses after a clicker question were also viewed unfavorably.

Challenges and Best Practices

Technology support and clicker cost

Although clicker technology is relatively easy to learn and use, studies show that technical problems during lecture remain a major cause of student negative attitudes (Draper & Brown, 2002; Zhu et al., 2006, 2007). Instructors and students may encounter a wide range of technical problems with clickers. For example, Zhu et al. found that students faced difficulties logging in and finding the network, but that faculty, on the other hand, tended to struggle with software issues, correctly displaying students' responses, and properly managing students' records. Although faculty may receive some training before using clicker technology, they need to reach a certain level of proficiency. Instructors should make sure that the software is stable so that fewer problems will occur when they actually use the clicker system in the classroom. It may not be necessary to offer training to students, but there should be a designated place where students can get help should they have problems with their clickers. Since technical problems sometimes surface in the first couple of class sessions, students should have the opportunity to practice responding to clicker questions before faculty test them during lecture and link their responses to course grades.

The cost of clickers is another common student complaint (Zhu et al., 2006, 2007). Concerns about costs are exacerbated when students don't see the value of using clickers during lecture. It is important for faculty to be sure that they will really use clickers consistently in class before requiring students to buy them. With tight instructional technology budgets, students will most likely need to purchase their own clickers. However, there may be innovative ways and models for reducing clicker system costs. For example, in large schools and colleges, it is a good idea to select a single vendor so that students don't need to purchase multiple clickers. Other cost-saving strategies include negotiating with vendors for better prices and establishing a clicker buy-back program.

Writing effective clicker questions

Preparing the right questions for clicker use is just as important as learning how to operate the technology. By writing effective questions, instructors will ensure a closer

connection between clicker questions and course learning objectives (Beatty, Gerace, Leonard, & Dufresne, 2006).

Different questions elicit different responses and require different levels of cognitive engagement. Knowledge-level questions ask for simple recall of facts and data without assessing them critically, whereas analysis, synthesis and evaluation questions require critical thinking and judgment. When faculty are simply assessing students' basic understanding, a knowledge-level question may be appropriate. But when faculty wish to engage students in thinking critically about course content, a knowledge-level question may fall short of reaching the goal. For example, Mazur (1993) found that students in his physics class could manipulate equations but had limited understanding of the principles behind the math. As a result, he focused on concept questions that asked students to interpret data or explain equations rather than recall facts or do calculations.

In addition to writing questions that measure the given learning objectives, faculty may need to learn techniques for writing effective multiple-choice questions. Practical suggestions from Wit (2003), Beekes (2006), and Draper and Brown (2002) for writing effective questions include the following:

1) Distinguish between students' knowledge of jargon and their understanding of concepts;
2) Create wrong answers (distracters) that seem very logical or plausible to students to prevent them from easily eliminating wrong answers;
3) Limit the number of answer choices to five or less; and
4) Consider including "I don't know" as an answer choice to prevent students from guessing.

More resources for writing better multiple-choice questions are available at the CRLT website: http://www.crlt.umich.edu/tstrategies/tsgi.html.

Changing roles for faculty and students

Challenges to the adoption of clickers go beyond learning to use the technology. Faculty must also learn pedagogies that are appropriate for clicker use (Judson & Sawada, 2002; Simpson & Oliver, 2006). In fact, the use of clickers implies not only changes in the way faculty usually teach, but also new expectations for both faculty and students. Most large classrooms on college campuses are designed with hundreds of fixed seats and a teaching podium located far away from the students. This physical environment usually leaves the faculty at the center of the stage, delivering the lecture with little or no audience participation and interaction. Both faculty and students are fairly familiar with this instructor-centered teaching environment. As a result, they may be resistant to modifying their teaching practices and adjusting their learning behaviors.

Because clicker questions can lead to unexpected responses from students, instructors may discover that they need to supplement explanations, add examples, adjust the pace or alter the lecture sequence in order to ensure that students understand the material. Some instructors may find the change in teaching style daunting. They may benefit from talking about their concerns with colleagues who have used the technology or observing a class to see how the technology is being used. They can also talk to instructional consultants at the Center for Research on Learning and Teaching (CRLT). CRLT consultants can discuss best practices for clicker use, arrange for visits to classes in which clickers are being used, help plan for integrating clickers into teaching, and observe and give feedback to faculty using clickers.

Students, on the other hand, can no longer sit quietly, passively take notes, and then digest the information after class. They will need to be more prepared for lecture in order to respond to clicker questions. They will also need to think more about the materials covered in lecture in order to provide possible solutions to the problems presented and be able to defend their answers. Students thus join the instructor in becoming an integral part of the lecture and active designers of their own learning experience. However, some students may resist taking on these additional responsibilities. They might not see the need for their active involvement during lecture, or they might feel that the instructor is relinquishing responsibility for teaching the class.

To help students adjust to their new roles, faculty should clearly explain their rationale for using clickers and active learning. Students also need to understand the nature of their responsibilities, such as actively participating in lecture and bringing clickers to class. Finally, student buy-in is likely to increase if faculty use clicker technology for meaningful exercises early in the class and continue to use clickers regularly throughout the term.

Recommendations for Using Clickers

Careful planning is the key to avoiding pitfalls when using clickers to teach. New users may feel excited about the technology and, at the same time, overwhelmed by the various opportunities to make use of clickers in teaching. Figure 1 contains recommendations for using clickers effectively in teaching.

Figure 1: Recommendations for Using Clickers

1. Make time to learn about the technological skills and pedagogical practices needed to use clickers effectively.

2. Know how the clicker system works before bringing it to the classroom. If you are not well prepared technologically or pedagogically for using a clicker system, it is recommended that you postpone using it until you are ready.

3. Know where to turn for technical support and where students can go for technical assistance. Also, make technology support information available to students on the first day of class.

4. Examine your own teaching style and establish clear goals for using clickers in class.

5. Explain to students the link between the use of clickers and course goals, clarify how clickers can help students achieve the learning objective(s), and explain to students why clickers are being used in the course.

6. Clearly articulate your expectations of students and also establish rules and student responsibilities (e.g., it is students' responsibility to bring clickers to lecture every time).

7. Develop a pool of thoughtful and effective clicker questions for each lecture.

8. Use clickers in conjunction with teaching strategies such as "Peer Instruction" or "Think-Pair-Share" to improve students' conceptual understanding of the content, as well as their critical thinking, problem-solving, and decision-making skills.

9. When using clickers for the first time, think of the first couple of class sessions as experimental so that both faculty and students will have a chance to practice. It is not a good idea to give students tests using clickers on the first day of the class because some students may not have purchased their clickers yet.

10. Be sure not to allocate too many points to a single test that is given to students during lecture using clicker technology, since it may create anxiety and also generate temptation to cheat.

11. If clicker technology is used to track attendance, be sure to use the system for other purposes as well, such as assessing student understanding, generating ideas for class discussion, or engaging students in thinking critically about course content.

12. When using clickers in a lecture class, be sure to use them regularly and consistently.

13. When using clickers to diagnose students' understanding, be sure to comment on or explain students' responses, give students another question on the same topic if needed, or adjust lecture pace and sequence if necessary.

14. If using clickers to elicit feedback from students about the course, it is best to do so early enough in the term to implement changes.

For additional information and examples regarding the use of clickers, visit the page "Engaging Students in Large Lectures Using a Classroom Response System" at the CRLT website (http://www.crlt.umich.edu/inst/responsesystem.html).

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**Center for Research
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The University of Michigan
1071 Palmer Commons
100 Washtenaw Avenue
Ann Arbor, MI 48109-2218