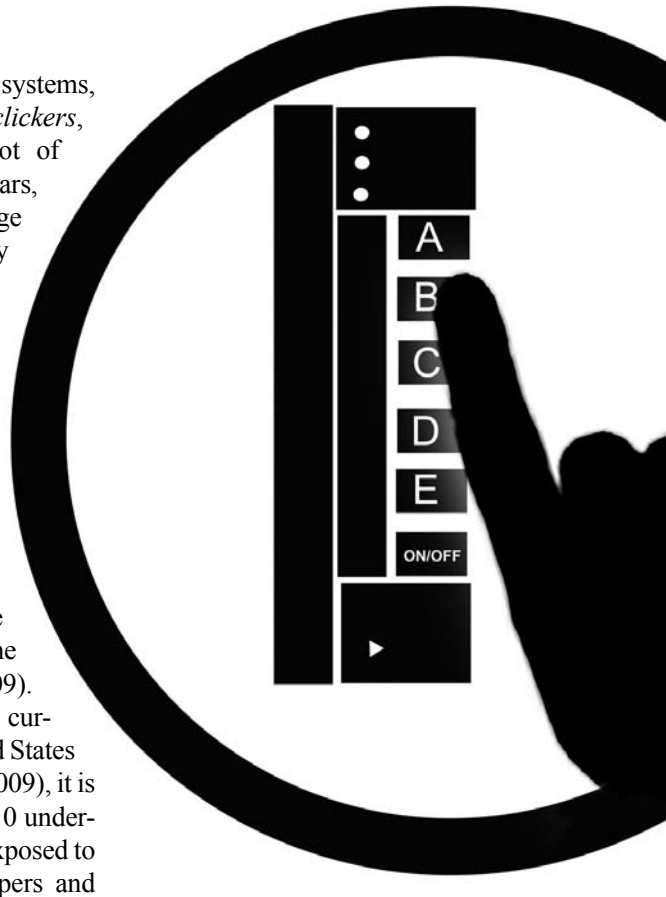
Clickers Promote Learning in All Kinds of Classes—Small and Large, Graduate and Undergraduate, Lecture and Lab

By Hannah Sevian and William E. Robinson

Clickers are a popular tool in large science classes. We find that clickers can also be used in small undergraduate- and graduate-level science classes, and to some extent also in laboratory classes, to achieve the same purposes as in large classes. Issues that can be addressed using clickers include fully engaging all students, identifying misconceptions, assessing preparedness, gauging the understanding of concepts, eliciting discussion, and identifying students who need additional help. However, much still depends on effective usage of the clickers, which in turn depends on time and effort invested by the instructor in developing effective questions and in working these questions into the class flow in a seamless manner.

Classroom response systems, better known as *clickers*, have received a lot of press in recent years, mostly with respect to large lecture classes and mostly very positive. At many colleges and universities, clickers have become the norm in large science classes. By one estimate, more than a million clickers are in use by college and high school students nationwide (Duncan 2008). One brand of clickers alone has reported that 700,000 students have used their system within the past two years (i>clicker 2009). With 11.7 million students currently in college in the United States (Bureau of Labor Statistics 2009), it is likely that about 1 in every 10 undergraduate students has been exposed to clickers. Myriad journal papers and trusted colleagues extol the virtues of clicker usage. Clickers can be used successfully to keep students engaged during lectures; elicit and address prior understanding, including misconceptions; obtain accurate formative feedback on how well students are learning what we think we are teaching; facilitate peer instruction and discussion; collect multiple trials of data from experiments conducted during class; and improve attendance in class (Judson and Sawada 2002). It is no surprise, and completely appropriate, that considerable effort has focused on documenting how clickers are used and impact student learning in large classes (e.g., Debourgh 2008; Mayer et al. 2009) because there is more potential to have a greater positive influence on learning outcomes when more students are affected, and large sample sizes make quantitative analyses more feasible.



But what if clickers were also just as useful in small classes? You might think that surely in small classes we can already adequately gauge the progress of our students; readily identify their misconceptions; easily tell if they are struggling with concepts; judge whether they have come to class prepared; and, of course, keep them fully engaged in learning during our classroom presentations. We don't need to bother with clickers in small classes! Or do we?

After some soul-searching, two of us at our university realized that we were as much in the dark in our small classes as we were in our large lecture courses. Plus, we weren't 100% sure that we actually had a better grasp of what was going on in our graduate classes than in our undergraduate classes. Having recently become familiar with clickers, we decided that adopting clickers in our classrooms—both large and small, both undergraduate and graduate—would give us the opportunity we needed to better understand our students and modify our teaching to better address their needs. A small internal grant enabled us to experiment with and compare using clickers within the range of classes we teach: two mid-size undergraduate general chemistry lecture courses (60 and 120 students, respectively), three small undergraduate environmental science laboratory sections (18 to 21 students per section), and one small graduate-level environmental toxicology lecture course (5 students). Over the course of two semesters, we kept track of all issues we encountered with using clickers, the clicker questions we used, our processes in developing them, and our reflections on how our use of clickers worked in advancing learning in our courses. We got together periodically to discuss these ideas. We report here a summary of our findings and reflections.

Initial decisions and logistics

Our first challenge was choosing which clicker system to use from among the many on the market. All the clickers we considered were small, handheld transmitters that operate in the infrared-radio region of the electromagnetic spectrum. A base unit (receiver) is connected to the instructor's laptop computer, which drives the software needed to collect, tally, display, and store student polling results. Some clickers are quite elaborate, with multiple keys for transmitting a variety of advanced text and numeric responses. Ultimately, we were swayed by the simplicity of using the i>clicker system (i>clicker 2009). Because we both use PowerPoint presentations, we found the seamless integration with our lecture styles appealing.

There were many other features in our choice that fit well with how we teach. We found the software easy to learn and implement. It enables an instructor to tally and save polling results, maintaining a "print screen" that matches the question that is on the screen at the time that the clicker polling is activated. This helped us later when reviewing the results, particularly while preparing midterm reviews and exams. The system can display, at the instructor's discretion, either during or after polling, a bar graph depicting overall class results. This enabled us to share results with the class immediately, if we wished, and to gauge how well students were grasping the material with accurate input for making instantaneous decisions about pace. Because each individual student had a specific clicker, we were able to track individual responses and determine which students needed additional challenges or extra help. Aside from the on/off switch, the clickers we chose have only five buttons (A–E) and thus can best be used to answer multiple-choice or true/false (or other dichotomous) questions. Initially we found this constraining, but it turned out to be beneficial because it caused us to consider very carefully how to use questions to move learning forward. In fact, the overarching finding from our exploration was that more depends on the clicker questions asked than anything else. We will return to this later.

In our large classes, we experimented with loaning out clickers to students for the semester, because we had purchased several hundred clickers using our grant. For the most part, students were appreciative of not having to purchase the clickers (ours is an urban, highly diverse, public commuter university, where the vast majority of students work and support themselves as well as family members). Students were responsible for the clickers, treated the equipment loan respectfully, and returned the clickers at the end of the semester. However, the added work of keeping track of the loans and tracking down students who dropped the course or did not return their clickers immediately at the end of the semester, coupled with the fact that many students needed the same brand of clickers in other courses at our university, convinced us that it is better for students to purchase their own clickers for large classes. In our small classes, we maintained baskets of clickers with students' names taped to individual clickers, which we brought to class each time. Each student picked up the clicker at the start of class and returned it when class ended that day, thus avoiding the problem of students forgetting to bring their clickers to class.

Using clickers effectively

Woelk's (2008) categorization of clicker usage is an accurate description of how we used clickers. Taking the student's point of view, clicker usage falls into two main categories: (1) "I am" (i.e., I am here, I am prepared, I am interested) and (2) "I do" (i.e., I learn, I understand, I apply). We generally designed our clicker questions in accordance with a question-driven instruction pedagogy (Beatty et al. 2006). We found that we tended to ask more "I am" category questions near the beginning of a class and just prior to introducing new concepts, whereas the "I do" category of questions tended to unfold as a class proceeded, while approaching transition points between topics, and as a class period came to a close.

We found several issues that transcend all types of classes (small vs. large, lecture vs. laboratory, undergraduate vs. graduate). Clickers are most effective when their use is transparently integrated with the content. In other words, clicker use should not disrupt the lesson, but rather should

sustain the flow of the class. We were best able to accomplish this when we used clickers throughout the class period. Rather than stopping the class ("And now for a couple of clicker questions!"), we found it worked best to lead into and out of clicker questions fluidly. For example, we used clickers to provide input as part of the discussion of a topic (e.g., to elicit prior conceptions, poll opinions to fuel a debate, collect predictions of an experimental outcome) or for students to practice using the skill or thinking process just taught ("dipsticking" understanding). We found that students responded best when we did not have predictable times or patterns of clicker use, preferring instead when we "mixed it up" from class to class.

There are, nevertheless, differences in how clickers can be used most effectively in each type of class (small vs. large, lecture vs. laboratory, undergraduate vs. graduate). There is ample research and guidance on how to use clickers effectively in large undergraduate lecture classes (Hatch, Jensen, and Moore 2005; Ribbens 2007; Skinner 2009), and we found evidence (e.g., the distribution of the types of questions we used, typical indicators in students' comments on evaluations) that we approached and often achieved successful use of clickers by these standards. Therefore, we will focus our attention here on the contrasting types of classes.

Figuring out how to use clickers effectively in laboratory sections was challenging. Because labs are meant to be primarily hands-on learning, it is difficult to insert clicker questions in the middle of the lab exercise when students are busy with the lab activities. When labs are inquiry based, not all students progress at the same pace, and if clickers are used, care must be taken not to spoil the thrill of discovery. Clickers can be used effectively at the beginning of the lab to determine if students are prepared, present, and interested, and to find out if students have misconceptions that need to be addressed before the activities start. Clickers can be used at the end of the lab, when student lab results are being shared and compared, in order to assess what students have learned. The questions can open discussion on why different results may have been obtained by different groups of students and can push students to generalize the lab findings and apply them to other situations (Eisenkraft 2003).

Undergraduates enrolled in our small laboratory sections appreciated clicker use (see Table 1). During the end-of-course summative evaluation, 88% of the undergraduates who participated in the evaluation ($N = 94$ respondents) felt that using the clickers was not "a waste of time." Students were very interested in how their peers answered each of the questions. It reinforced their confidence when they answered correctly and pointed out, anonymously, if they answered incorrectly.

What surprised us most, however, was that graduate students in a very small ($N = 5$) graduate lecture course felt the same way (see Table 1). Graduate students felt that clickers were most useful for stimulating discussion, whereas undergraduates chose a wider

TABLE 1

Student assessment of clicker usage obtained during end-of-the-course summative evaluations.

	Undergrad student response	% Undergrad student response	Graduate student response	% Graduate student response
A waste of time	11	12%	0	0%
Useful for sharing opinions among students	13	14%	1	20%
Useful for comparing student's results with the rest of the class	17	18%	0	0%
Useful for getting a sense of what the class already knows about a topic at the start of the class	37	39%	0	0%
Useful for stimulating discussion	16	17%	4	80%

Note. Undergraduates were enrolled in seven environmental science laboratory sections (12–23 students enrolled in each section over a two-year period; total number of students responding = 94); graduate students were enrolled in a small graduate lecture class (5 students; all responded).

variety of reasons for clicker's usefulness. In particular, when graduate students were specifically asked near the end of the semester whether using clickers in the course helped them to learn, all five of them unanimously responded with the second highest option, that clicker usage "helped considerably." (The options were: A, they had no impact; B, helped only slightly; C, helped somewhat; D, helped considerably; E, helped enormously.) Our fear had been that graduate students would disparage clicker use as just a gimmick. However, they readily accepted them and told us they looked forward to the immediate revelation of correct and incorrect answers to each question. They seemed to cherish competing with each other to get the right answers and challenging themselves to be able to answer more questions correctly. Their groans (when they answered incorrectly) and cheers (correct answers) told us they were emotionally, as well as intellectually, engaged in learning.

One of the greatest values of using clickers is the opportunity to get an immediate and accurate reading of what students do and do not understand. We learned that we had fooled ourselves by thinking that in small classes we can easily tell if students "get it" just because we are operating in a more intimate learning environment. In addition, it shocked us to learn that, even in very small graduate classes, we had often failed to recognize students' misconceptions, even after years of teaching experience. By using the clickers, we were able to pick up these misconceptions and naïve preconceptions and adjust our presentations to respond to them. Although it took class time to do this, the investment was returned when the class was able to build more quickly on well-founded understanding.

In all our classes, for us the most valuable aspect of using clickers was how their use facilitated more equitable participation by students. Our enhanced ability to document attendance, determine preparedness for class, and

instantly grade pop quizzes enabled us to use data to identify and follow up with students who were lagging behind and to make earlier efforts to channel them toward appropriate resources. In small classes (both undergraduate and graduate), there are always small numbers of students who tend to dominate discussion and other students who tend not to participate. We found that using clicker questions more often enabled the voices of the quieter students to be heard, and by establishing new routines in our classes, the norm of discussion-dominant students speaking first was disabled.

It's not all rosy

If clickers have so many benefits and are so easy to use, why don't all faculty readily adopt them for their classes? The main reason probably revolves around time and effort. There is only so much time in a day, and learning a new (additional) technology as well as revising our teaching to incorporate it takes time that cannot then be spent on something else. Our reasons for initially resisting the adoption of clickers were similar to reasons we heard from many of our colleagues. One of us did not want to rock the boat while being junior faculty, and the other was not really "into" computers or gadgetry. Neither of us had a Facebook page or "Twittered," and one of us still doesn't own a cell phone. Aversion to new technologies was one of the reasons why we chose the simplest clicker system we could find. Transparency of implementation with traditional lecture format also suited well our desire to have our teaching innovations remain as inconspicuous as possible.

The most hidden time sink, and also the most important factor in successful use of clickers to promote student learning, is designing good questions. Good questions must be well thought out and specifically address a pedagogical objective of the course (Beatty et al. 2006; Skinner 2009). To this end, we found the book, *Quality Questioning* (Walsh and Sattes 2004), to be most helpful, particularly around formulating questions that activate thinking and developing questioning strategies to scaffold more critical thinking, deeper understanding, and meaningful discussions. Although it required significant time investment to develop each good question, we believe the benefits for our students and ourselves were well worth the effort. Thus, unfortunately, we can only partially allay our colleagues' fears of having to invest time and effort to conquer clicker technology (hardware, software, and effective use).

So, what comes next?

Effective pedagogies of clicker usage are relevant to many who teach in

higher education, as evidenced in several recent articles in this journal. Because how faculty instruct is linked to how students learn, it makes sense to pair the study of why and how faculty use clickers with how clickers motivate students to learn. Similar to other studies, Koenig (2010) found that reasons why faculty choose to implement this instructional technology include addressing issues of student success and engaging all students, contributing to a more interactive and inclusive learning environment, fostering rapid feedback, and facilitating the taking of attendance and encouraging attendance. Conquering the logistics of clicker usage is relatively straightforward, and this enables movement of the instructional technology beyond its original intended uses. Hunter et al. (2010) found that similar advantages exist when adapting clickers to collect and display student data in the laboratory. These authors present compelling findings on students' positive self-reported reactions to the use of clickers to compare student analyses of large, biological data sets in real-time. Clickers also increased the capacity of instructors to monitor students' progress in the laboratory. Milner-Bolotin, Antimirova, and Petrov (2010) conducted a case study on the use of clickers in small (N = 25) upper-level undergraduate courses, aiming to learn whether it can be done effectively, what students and instructors perceive as the value added, and challenges that attend the circumstance of the adaptation to upper level. Similar to what we present in this paper, challenges that Milner-Bolotin et al. elucidated include the refutation that content coverage is critical and clicker usage diverts time from more efficient direct instruction, and that designing effective clicker questions is hard work.

We are sold on the value of using clickers. It is clear that many students and faculty find clickers to add value to teaching and learning. The same values and challenges have been verified in a variety of contexts, including large and small classes; upper and lower levels; undergraduate and graduate courses; laboratory and lecture settings; and many disciplines such as nursing, business, and science, math, and engineering. Much that is known about how people learn can be addressed by careful pedagogical use of clickers. However, much depends on the investment by instructors in planning the use of clickers in ways that promote learning. It may be time now to move beyond documenting practice, self-reporting, and the affective domain to examine what can be done to surmount the challenges that have been identified and determine why clickers work. ■

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References

Beatty, I.D., W.J. Gerace, W.J. Leonard, and R.J. Dufresne. 2006. Designing effective questions for classroom response system teaching. *American Journal of Physics* 74 (1): 31–38.

Bureau of Labor Statistics, U.S. Department of Labor. 2009. *College enrollment and work activity of 2008 high school graduates* (News Release USDL 09-0454, April 27). Available at *www.bls.gov/news.release/pdf/hsgec.pdf.*

Debourgh, G. 2008. Use of classroom "clickers" to promote acquisition of advanced reasoning skills. *Nurse Education in Practice* 8 (2): 76–87.

Duncan, D. 2008. Tips for successful "clicker" use. Available at *www.colorado.edu/its/cuclickers/instructors/Tips.pdf.*

Eisenkraft, A. 2003. Expanding the 5E model. *The Science Teacher* 70 (6): 56–59.

Hatch, J., M. Jensen, and R. Moore. 2005. Manna from heaven or "clickers" from hell: Experiences with an electronic response system. *Journal of College Science Teaching* 34 (7): 36–39.

Hunter, A., J. Rulfs, J.M. Caron, and M.A. Buckholt. 2010. Using a classroom response system for real-time data display and analysis in introductory biology labs. *Journal of College Science Teaching* 40 (2): 19–25.

i>clicker. 2009. *www.iclicker.com*.

Judson, E., and D. Sawada. 2002. Learning from past and present: Electronic response systems in college lecture halls. *Journal of Computers in Mathematics and Science Teaching* 21 (2): 167–181.

Koenig, K. 2010. Building acceptance for pedagogical reform through wide-scale implementation of clickers. *Journal of College Science Teaching* 39 (3): 46–50.

Mayer, R., A. Stull, K. Deleeuw, K. Almeroth, B. Bimber, D. Chun, M. Bulger, J. Campbell, A. Knight, and H. Zhang. 2009. Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology* 34 (1): 51–57.

Milner-Bolotin, M., T. Antimirova and A. Petrov. 2010. Clickers beyond the first-year science classroom. *Journal of College Science Teaching* 40 (2): 14–18.

Ribbens, E. 2007. Why I like clicker personal response systems. *Journal of College Science Teaching* 37 (2): 60–62.

Skinner, S. 2009. On clickers, questions, and learning. *Journal of College Science Teaching* 38 (4): 20–23.

Walsh, J.A., and B.D. Sattes. 2004. *Quality questioning: Research-based practice to engage every learner.* Thousand Oaks, CA: Corwin Press.

Woelk, K. 2008. Optimizing the use of personal response devices (clickers) in large-enrollment introductory courses. *Journal of Chemical Education* 85 (10): 1400–1405.

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