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To Click Or Not To Click: That's The Question

by Johnny El-Rady

It is not unusual in higher education these days to have classes with large enrollment. Indeed at the University of South Florida (USF) (enrollment 41,000), large classes are the norm. In the eight years during which I have been an instructor in the Biology Department at USF, my mid-level and lower-level classes have had enrollments ranging from 100-300 students. This large class size generates a few problems, especially in terms of engaging students in active learning. While a well-designed traditional lecture can be very effective, students can engage more directly with the material when they actively take part in their learning instead of simply passively receiving information. Another problem in large enrollment courses is low attendance, especially by students taking a non-major course.

Since the fall of 2000, I have taught BSC 2035, a general education course for non-majors entitled Sex and Today's World. It is a three-credit course with no laboratory component, and its title is quite misleading. From the very first lecture, I emphasize that BSC 2035 is a biology course dealing with human reproduction, telling students, "We will discuss what good is sex, not what is good sex." Since this approach is plainly not what many students hope for, attendance rates plummet after the first lecture; attendance rates generally average at about 50% over the course of a semester. While attendance is not required and while this attendance rate may not be unusual in large enrollment classes for non-majors, it is still rather disappointing. Yet another problem the course presents stems from the student composition of the class. In a typical semester, the 125-150 students represent five to six colleges and 30-35 majors. About 75% of the students are underclassmen taking their first college-level science course. The diversity of majors and levels makes it even more difficult to engage students in an active learning environment. The students are generally reluctant to ask or respond to questions. In-class assessment is onerous, especially in the absence of a teaching assistant, so it is hard to gauge students' learning in the midst of a lecture. Consequently, the course grade has been based on performance on three midterms (the highest two count as 50%), a mandatory final exam (40%), and a student portfolio/project (10%) due at the end of the semester.

Electronic classroom voting systems present one method for overcoming the aforementioned problems. These systems are known by various names, including Audience Response System (ARS), Group Response System (GRS), Student Response System (SRS), and Personal Response System (PRS). All of these systems use wireless keypad technology that allows for real-time interactive student-instructor communication. Students use pocket-sized transmitters ("clickers") that work on infrared signals to respond to questions that the instructor poses. Students' responses are submitted to a central server, and the results are tallied instantaneously and displayed in different graphical formats for the entire class. This type of technology has been used to enhance the educational experience in many disciplines, including physics (Burnstein and Lederman 2001), biology (Woods and Chiu 2003), earth sciences (Greer and Heaney 2004), pharmacy (Slain et al. 2004), and family medicine (Schackow et al. 2004). To promote a more interactive teaching/learning experience in my class, I investigated the use of this technology in Fall 2004 and Spring 2005.

Integration of eInstruction's Classroom Performance System

There are a number of vendors for electronic voting systems, including Classtalk Classroom Communication System (CCS), eInstruction's Classroom Performance System (CPS), Hyper-Interactive Teaching Technology (H-ITT), and Turning Point System. I used eInstruction's CPS because the course requires a McGraw-Hill textbook and eInstruction is a partner of McGraw-Hill Higher Education (MHHE).

To prepare to integrate CPS into BSC 2035, I participated in all four hour-long online information sessions that MHHE offers on the CPS technology. These sessions, delivered via WebEx, cover issues such as installing the hardware, navigating the software, creating class content, using the grade book, and generating reports. The use of the technology also required some front-end labor (Exhibit 1). Because I was concerned about the added cost to students and because I needed more experience handling the system, I was hesitant to include CPS as a course requirement in the first semester, so I decided to use it for extra credit (Exhibit 2).

The class had an initial enrollment of 126 students, 111 of whom remained in the course for the entire semester. In order to set up the system, become familiar with it, allow interested students enough time to register on CPSOnline (105 eventually did), and perform a few trial runs, I waited until Week 6 of the semester (after Exam I) to officially launch the CPS technology. While students may have been interested in the extra-credit, the CPS gradebook indicated that many of those students never actually used CPS in class. It is possible that because CPS was not required, these students did not take the clickers seriously. However, some students did use the clickers in class on a regular basis; a total of 60 students (about half the class) participated in at least 75% of class activities. 43 students missed only three or fewer lectures. At the end of the semester, 28 students (about 25%) earned the full 2.5% extra credit.

Encouraged by these results and by the students' end-of-term evaluations, I decided to make CPS a requirement for the Spring 2005 course (Exhibit 3). A total of 125 students out of the 128 enrolled in the course registered on CPSOnline in Spring 2005. We started using CPS in Week 3 of the semester. In order to get maximum credit, students had to keep up with the material, be there for the entire class, and participate in class activities using the clickers.

At the start of every lecture, I administered a quiz based on the material from the previous lecture; the quizzes were short, typically consisting of two or three multiple choice questions. While paper quizzes take time to collect and require a lot of time to grade, especially in large-enrollment classes, CPS technology allows for instantaneous grading and real-time feedback. The CPS receivers collect students' answers and relay them to a computer to display on a screen; on the screen, each student has a number that changes color once the answer has been received, and at the end of a preset time (2-4 minutes), the answers are summarized and displayed using different statistical formats.

Such instantaneous grading offered several advantages to the students as well as to myself as the instructor. On the one hand, students no longer had to wait for a few days to get their quiz results. On the other hand, they could no longer afford to wait for the last day(s) to study for the exam; CPS quizzes encouraged students to keep up with the material on a very regular basis. Moreover, because the CPS software allowed student response scores to be automatically recorded into the gradebook (Exhibit 4) while also generating comprehensive grade reports for particular activities (Exhibit 5), class assessment for these activities became a much less burdensome process.

I also used CPS during lecture by posing class participation questions to test students' comprehension of the key concepts/principles I had just presented to them. I encouraged students to form groups of two or three to go over each question, gave them enough time for consultation, and then asked them to submit their responses individually. I then went over the results with them. On occasion, I used Peer Instruction (PI), a technique developed by Eric Mazur (1997), by requiring students to answer the question first without discussion and then again after a short period of group discussion with their peers. This activity engages students directly in teaching and learning. The class participation questions provided me with a way to gauge instantaneously whether the students understood the topic at hand; in turn, the distribution of student responses to some questions prompted further exploration of potential misconceptions and allowed for discussion of one or more follow-up questions. This approach promoted interactivity and discussion in class as well as active engagement in peer learning and teaching. Because I posed these questions at 20-30 minute intervals throughout the 75 minute class period, this approach also provided timely breaks from the routine of lecture.

At the very end of the lecture, I took attendance in order to reward those students who stayed until the end. Before CPS, attendance in the class averaged about 50% throughout the semester. In the Spring 2005 semester, the lowest attendance rate was 65% (in the lecture following Exam III) and the mean attendance was about 85%. Of course, mere attendance does not necessarily equal learning. However, the high attendance rate coupled with the quizzes and class participation activities did provide the means for enhanced learning.

Quantitative Data

The average on Exam I in Fall 2004 was approximately 61%. Students are not allowed to keep the exam, and I have many fail-safe mechanisms to ensure that they do not. In Spring 2005, I administered the exact same Exam I to a class of about the same size with roughly the same distribution of student major/level. The average was approximately 71%.

In order to determine if any significant difference existed between the two Exam I grades, I performed statistical analysis on the data using SigmaStat software version 3.1. The significant level for all tests was set at p=0.05. The normality test failed, so I used a Mann-Whitney Rank Sum Test to analyze the untransformed data; in addition, I reran a T-test with square-root transformed data. Both tests revealed that the difference in exam scores between the two semesters was significant (p=<0.001) (Exhibit 6).

Encouraged by these results, I decided to administer all of the exact same exams from my Fall 2004 class to my Spring 2005 students. The average improvement was about 5 percentage points from Fall 2004 to Spring 2005 (Exhibit 7). These results suggest that electronic classroom voting systems improve student retention of course material.

Evaluation of CPS

In order to get feedback about CPS, I administered a survey in which I asked students to complete the following two sentence stems:

- The best thing about CPS is…
- The worst thing about CPS is…

I gave this survey at the end of the fall semester, and right after Exam I in the spring semester. Students submitted a total of 139 responses, the vast majority of which were anonymous (Exhibits 8, 9, 10, and 11).

While students generally praised the CPS system, I would first like to address their most significant complaint. A tally of the results revealed that about 55% of the students complained about some aspect of signal reception. The keypads we used in BSC 2035 operated by infrared (IF) technology, which required unobstructed line-of-sight communication between transmitter and receiver (just like a television remote). Moreover, the technology was limited to a maximum ratio of transmitters to receivers, which, according to eInstruction, ranges from 90:1 to 100:1. These limitations caused the most significant problem in my use of CPS technology—a bottleneck effect in which too many students tried to send a signal at the same time. Initially, the classroom contained only two receivers. After the survey was conducted in the spring, another receiver was installed in the room, dramatically improving reception.

A newer version of the CPS keypads will further solve this bottleneck problem. These keypads utilize radio frequency (RF) technology, which relies on radio transmissions and thus eliminates the need for line-of-sight communication. In addition, the RF technology can support classrooms with as many as 1,000 students with just a single receiver unit. However, the RF technology costs more than the IF technology ($15 versus $4), and students indicated that the IF keypads and activation fees were expensive. Hopefully, eInstruction will be able to provide a solution that balances cost and signal reliability.

In addition to these challenges, classroom voting systems in general pose several potential disadvantages for traditional instruction. Like any technology, classroom voting systems are subject to both hardware and software problems. The CPS software is rather straightforward and eInstruction's customer support is generally prompt and very good; however, even in the absence of system malfunctions, it takes some time for an instructor to learn how to use the system. Likewise, it takes time to develop questions that are conceptual, challenging, and discussion-stimulating, and it takes additional time to load those questions into the system (Exhibit 12). Moreover, voting activities take time from traditional lectures. On average, a good conceptual multiple-choice question will consume anywhere from three to eight minutes. Thus, questions should be used sparingly to highlight certain points.

Despite these potential problems, I believe that the advantages of using electronic classroom voting systems far outweigh the disadvantages. For teachers, the technology provides a very fast way to take attendance and an efficient way to learn about course content and style. More importantly, classroom voting systems provide a real-time assessment of material that students are failing to grasp, thereby allowing teachers to concentrate on these "problem areas."

Conclusion

For students, the electronic classroom voting technology enhances the learning experience. In addition to encouraging attendance, classroom voting systems motivate students to stay focused; in any given lecture, students may be expected to discuss important concepts or principles with their peers and to answer questions accordingly. Moreover, voting systems increase students' interest in course activities. Using the clickers is fun and addictive, allowing students to push buttons and compare themselves to the rest of the class. Through the use of such systems, a class becomes less formal and the atmosphere much more student-centered. Most importantly, voting systems promote interaction and active learning. Instead of information merely passing from the instructor to students, students teach and learn from each other, and teachers can use the class response to generate further discussion. Because individual responses are posted anonymously, the technology is also quite effective for sensitive topics, such as those dealing with ethics.

Indeed, qualitative survey responses from students have generally praised the system (Exhibit 13). Although a quantitative assessment of learning as a consequence of electronic classroom voting technology may be difficult, it is certainly desirable. The results of my comparison of "pre-CPS" and "post-CPS" exam grades are encouraging. However, student satisfaction alone may be reason enough to use this system in class. Further studies with control groups may be warranted, but I strongly endorse this technology as an effective tool to promote student engagement and active learning.

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