Wireless response technology in college classrooms

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Recent advances in wireless technology provide interesting and effective solutions to two perennial problems in large-classroom teaching. The first problem is to entice students into participating actively. In lecture classes, a variety of diversions can conspire to distract students from the lecture podium. Some of these problems can be alleviated by alternatives to straight lectures—for example, interactive learning techniques such as group discussion or student presentations. However, in large classes, there rarely is time for more than a small fraction of students to voice answers or opinions. The second problem is monitoring student comprehension. As instructors, we probably feel in general that our lectures are good, and that the students are learning *quite a bit*. Nonetheless, in large classes, we usually have no simple way of assessing how well students understand the material, other than by their mid-term and final test scores. From day-to-day interactions in the classroom, it is extraordinarily difficult to gauge understanding. Conversing with one's class can help, but discussion with a small (often the same) subset of students is likely to be seriously misleading about class-wide comprehension.

Both problems can be addressed with new wireless technologies now available. Over the past year, we implemented one such system, the Classroom Performance System (CPS) made by eInstruction.com, in our classes at the University of Texas at Austin (Woods in biology; Chiu in physics). At the beginning of the semester, we announced to the students that they would be required to buy a CPS wireless response pad, essentially like a simple TV remote control. During most class periods, we posed questions, to which the students responded using the pads. A set of receivers at the front of the classroom collected the responses and sent them to a computer, which rapidly analyzed them and displayed the responses as histograms. Both questions and responses were projected via an LCD projector onto a large screen at the front of the class. The wireless system was less expensive, easier to install, and more robust than comparable hard-wired response systems.

Although more systematic study is needed, we think the technology significantly improved student participation and interactivity in the classroom. We often lecture with question/answer pauses, and the wireless system helped us to use these pauses effectively—by breaking up the monotony of a straight lecture and emphasizing important points. For us, the technology clearly indicated which topics were easy and hard, which topics were controversial, and in general how well the students understood the material.

Kinds of questions and possible uses.

Response pads have labeled buttons, which constrain the instructor to a multiple-choice format. Although this may seem like a significant constraint, the medium nonetheless is effective with a number of question types. The three main categories of questions that we posed were:

1. Fact or process questions. These questions assess basic understanding of a topic. An example is, “How long ago did the Earth form?” This basic type of question can be made less superficial—for example, one could show an animation of the molecular details of the HIV lifecycle (link to http://www.hopkins-aids.edu/hiv_lifecycle/hivcycle_txt.html), followed by sophisticated questions about which lifecycle description is correct.

2. Problem solving. In college courses, students often are required to solve problems through a chain of reasoning. Since the strength of the chain depends on its weakest link, we focus on examining individual links. Wireless questions posed in class tend to be short, typically involving one or two links (Exhibit 1: Understanding pivot, torque, and rotational motion). An effective solution to assessing such concepts has been to pose two or more answers that all appear reasonable.

3. Opinion or belief questions. These questions can provide interesting insight about prevailing attitudes in class. Some questions are sensitive enough (Exhibit 2: Human origins survey) that students are likely to give honest answers only if they can respond anonymously. This is problematic because the computer records all student answers and associates them with that student, based on a unique identifying signal put out by each pad. We made an end run around this problem by having students trade pads with each other.

Other kinds of questions may be more appropriate for other subjects or different teaching styles. In this respect, the tool is quite flexible—the only constraint is that the questions be posed in a multiple-choice format.

Benefits for students and instant feedback for instructors

The most valuable benefit for students is an increase in interactivity and class participation. In traditional large classrooms, students often feel that the class is impersonal—student input into class proceedings may never be required. The wireless system encourages all students to participate in every topic, regardless of how shy he or she may be. This is especially powerful when coupled with other interactive teaching techniques, such as discussion with their neighbors prior to answering wireless questions. Second, students know where they stand with respect to other students. After student responses are recorded, the computer displays a histogram of answers and indicates which answer is correct. If most of the class answers a question correctly, the students answering incorrectly may be motivated to read or think more deeply about the subject matter. Third, students can practice solving test-style questions. A common complaint is that test questions are not representative of the material covered in class, or in some other way surprised them. Daily use of CPS questions gives students repeated exposure to the kinds of questions that the instructor writes and emphasizes the concepts and ideas that the instructor thinks most important.

Altogether, the students thought it was fun and helped them to learn material presented in class (Exhibit 3: Class Survey). When Woods announced the technology to his class, a student near front shouted out, “It'll be just like Who Wants to be a Millionaire!” That

sense of enthusiasm persisted throughout the semester. Many students seemed amused that they would be able to have their answers register and count.

The tool is also eye-opening for instructors. In the classroom, we often ask “Did everyone understand that?” However, our response—“Great, let's move on”—often is prompted by a nod from a single student. Wireless response systems provide a concrete way around this problem. By asking response questions throughout a class period, instructors can stay in touch with the level of student understanding. Often, topics that we felt were difficult were in fact easy for the students, and *vice versa*. The net effect was that we could fine tune our teaching effort to the pace of student comprehension.

In our classes, the response pads appeared to increase rates of attendance (see Exhibit 3: Class Survey). This effect probably stemmed from two factors. First, if students felt that their input mattered to the functioning of the class, they may have been more likely to attend. Second, some fraction of the total points available to students depended on day-to-day participation. Each pad sends a unique identifying signal (associated with a particular student), and the computer keeps track of each student response. We had the CPS software generate a log file after each class session, and we used these files when assigning grades. Typically, we made 5 – 10 % of the course points available through wireless participation. These points usually were not dependent on answering correctly, just on participating. This policy encouraged participation without turning every lecture into an examination. However, one could also use CPS as a testing tool.

Pricing and distribution

At the University of Texas, we used what is called a “bookstore model.” The UT-Coop bought response pads from eInstruction and then resold them to students. The Coop agreed to sell pads to the students for about $34 (USD) each and to buy them back at the end of the semester for about half that amount. Although we felt that this cost was reasonable, it still was an extra expense that the students had to shoulder. Student reaction to this cost will depend strongly on how well integrated the technology is into the class material.

Each classroom was equipped with one or more receivers and, in some cases, a hub to coordinate signals from multiple receivers. A system with two receivers plus a hub can service a class with about 250 students, and it costs about $1000. In our college, the dean's office recently equipped seven classrooms for a total hardware cost of about $7000. This expense is significantly less than some other ways of equipping classrooms with response technology. For example, equipping large classrooms with hard-wired response technology can cost more than $20,000 per classroom. Thus, the wireless system represented a significant savings and was more reliable than the hard-wired system. Of course several other items are necessary. A computer must be available to run the software (software is free) and collect student responses, and an LCD projector to display the results. To minimize additional expenses, our college targeted technology classrooms that had been previously equipped with computers and projectors.

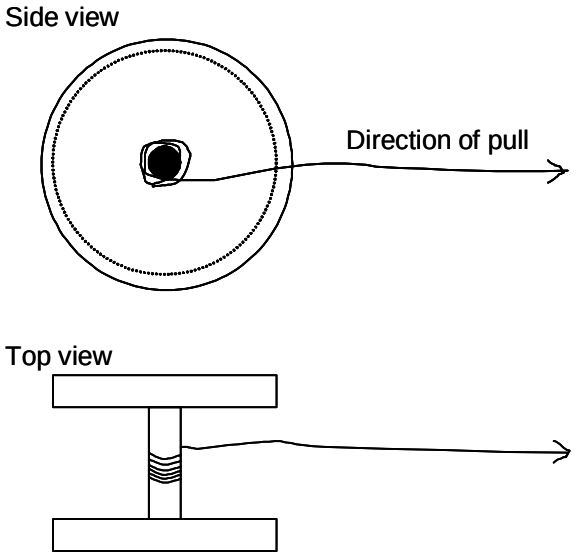
Conclusion

The wireless technology is an effective tool to engage students and to understand better how well they grasp material and what they think about current issues. It is relatively inexpensive, easy to use, reliable, and readily integrated into previously established class material. We intend to continue using it in our classrooms and have convinced a number of our colleagues to adopt the technology as well. Additional information is available at the UT Wireless (CPS) Website.

Disclaimer: Art Woods and Charles Chiu are not affiliated with eInstruction.com and do not have any financial interest in the company.

Exhibit 1: Understanding pivot, torque, and rotational motion. Charles Chiu used the wireless system in the UT International Teaching Assistant workshop in Fall 2002 to illustrate how one can integrate the tool in physics classes.

The lesson covers the concepts of pivot, torque, and rotational motion. The material was motivated by the following problem. Suppose you are pulling on a string wound around the center part of a spool as shown below.



Which way will the spool move? Here is how the teaching assistants responded using a demo system with a total of 25 responses:

To the left	To the right
60 %	40 %

In fact, the correct answer is 'to the right.' Over half of the answers were incorrect, which set up the subsequent lecture on the reasoning chain necessary to arrive at the correct answer. The lecture included discussion of pivot points, torque about a pivot, and the equation of rotation. The value of the wireless system is that it forced everyone to commit to an answer before seeing which way the problem turned out. Because the intuitive answers of a large fraction of the respondents were wrong, my impression is that they subsequently were more motivated to think about and understand the physical principles involved.

Other physics questions are available at the Interactive Quiz Library (link to http://www.ph.utexas.edu/~itiq/iq/) at the University of Texas.

Exhibit 2: Human origins survey. Art Woods taught BIO301M (Ecology, Evolution, and Society) during the spring semester of 2002 at the University of Texas at Austin.

After several weeks of lectures on human evolutionary history, I presented a lecture on evolution and creationism (74 students attending that day). At the beginning of class, I used the wireless system to ask a question developed by the Gallup Poll organization. I asked students to trade wireless pads with a neighbor so that there would be no way for me to associate answers with specific students.

'Which of the following statements comes closest to your views on the origin and development of human beings?—

A. Human beings have developed over millions of years from less advanced forms of life, but God guided this process;

B. Human beings have developed over millions of years from less advanced forms of life, but God had no part in this process;

C. God created human beings pretty much in their present form at one time within the last 10,000 years of so.'

D. No opinion

Here are the percentages choosing each answer, along with responses of the American public (about 1,000 adults polled by the Gallup Poll organization in February of 2001, given the responses in random order).

	My class	American public
A	65	37
B	9	12
C	22	45
D	4	6

It was clear that my class held a diversity of viewpoints on the question of human origins, and that their beliefs differed from those of the American public at large. The numbers sparked a lively and interesting discussion. I believe the students subsequently were more engaged during the lecture I presented about the tension between the two viewpoints.

Exhibit 3: Class Survey

Using the CPS system, both of us polled our classes about how they liked using the response system. On the poll day, 83 students attended the biology class and 38 students attended the physics class. Here are response percentages to each of four questions

1. On a scale from A (a lot) to E (not at all), how much have you enjoyed using the wireless system?

	BIO 301M	PHY 303L
A	37 %	37 %
B	35 %	26 %
C	15 %	29 %
D	9 %	3 %
E	4 %	6 %

2. On a scale from A (a lot) to E (not at all), how much has the wireless system helped you to learn material presented in class?

	BIO 301M	PHY 303L
A	30 %	26 %
B	44 %	34 %
C	20 %	26 %
D	5 %	6 %
E	1 %	9 %

3. Does the wireless system help you to pay closer attention to the ideas and concepts presented in class?

	BIO 301M	PHY 303L
Yes	72 %	82 %
No	14 %	6 %
No opinion	15 %	12 %

4. Has the wireless system changed the likelihood that you attend class?

	BIO 301M	PHY 303L
Strongly increased	51 %	62 %
Somewhat increased	27 %	32%
No change	21 %	6 %
Decreased	1 %	--