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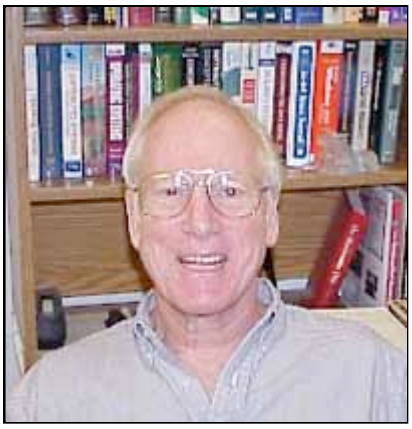
New Research Blog Available Here!!

Editor's note: Images are available here to accompany the story;otherwise contact Pam Frost Gorder.

STUDENTS WHO USE "CLICKERS" SCORE BETTER ON PHYSICS TESTS

COLUMBUS, Ohio -- Hand-held electronic devices called clickers are helping college students learn physics, according to a series of research studies.

Ohio State University students who used the devices to answer multiple-choice questions during physics lectures earned final examination scores that were around 10 percent higher – the equivalent of a full-letter grade -- than students who didn't.

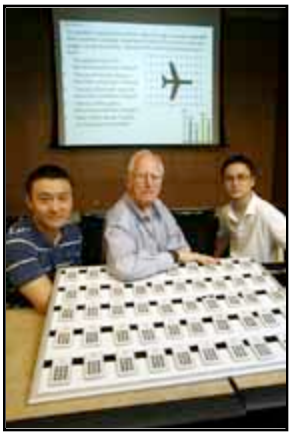

Bill Reay

The clickers also appear to level the playing field between male and female students. In clicker classes, male and female students performed equally well. In the traditional, non-clicker classes, male students outperformed female students.

To Bill Reay, professor of physics at Ohio State, these results suggest that clickers could potentially encourage more women to pursue STEM (Science, Technology, Engineering and Mathematics) disciplines.

"The U.S. industrial sector has expressed an urgent need for more scientists and engineers to enter the workforce, to maintain our technological edge in the future," Reay said. "We need to recruit more students -- male and female -- who otherwise might not study science. And it turns out that for women especially, clickers can be a valuable learning tool."

The Ohio State researchers reported their early results in the *American Journal of Physics* earlier this year. Additional results appeared in the June 2008 issue of the journal *Physical Review*



Special Topics - Physics Education Research.

Around the country, clickers are regularly used to maintain student attention in large lecture halls. At large universities such as Ohio State, even relatively advanced science classes may contain hundreds of students. Reay said that clickers are a good way to help students pay attention and learn in today's classroom.

"A hundred years ago, not so many people went to college, and classes were smaller. It was easier to engage students in learning," Reay said. "Now we have a class with 700 students in it. And the question is, how do you engage 700 kids? Well, clickers can do it."

In clicker classes, multiple choice questions appear on a large computer screen at the front of the lecture hall. Students hold the wireless devices, which resemble small calculators. They cast their votes for the correct answer based on their understanding of the part of the lecture that was just given. A bar graph shows the percentage of students voting for each answer.

As to why clickers seem to help female students more than male students, the anonymity of the devices may offer an advantage. In surveys, nearly all the students -- male and female -- said they liked having the ability to keep their answers private.

Physics educators have expanded the use of clickers at Ohio State by developing sequences of questions to determine if students really understand the underlying concepts of a lecture. The technique involves offering a series of questions -- typically three -- each with different wording and structure, but all designed to test the same concept.

One three-question sequence that Reay and his colleagues developed is used to test students' understanding of Faraday's Law. The class is shown a diagram of two wire loops of different sizes moving into a magnetic field, and asked which loop will experience larger induced voltage at the moment it enters the field.

For an introductory electromagnetics class of engineering majors, this is an easy question and Reay would expect more than 80

percent to answer it correctly.

"But not all students choose the correct answer for the right reason," he said. "A common misconception is that larger loops always have a larger induced voltage, which is not the case. That's why we then ask two more questions that involve loops of different sizes and shapes. The question-sequence method eliminates common student misconceptions, and helps students grasp the underlying concept in a short time."

The idea with clickers, Reay explained, is that both lecturers and students can gauge whether students understand the material in real time. If students don't understand something, the lecturer might try to get them to think about the topic in a different way, perhaps by discussing it amongst themselves to encourage understanding before moving on to a new topic.

Professors typically devote approximately 20 percent of a class to clicker questions, and the rest to traditional lecture and discussion. "Clicker questions are like icing on a cake," Reay said. "Icing complements the flavor, but you need both for a tasty cake."

Students aren't required to use the clickers, but Reay said that participation over the years has held relatively constant at 90 percent. Small incentives, such as grading clicker questions or offering extra credit, can raise participation to 98 percent.

Students seem to like the clickers.

“When we conduct our quarterly surveys, we find that the percentage of students enthusiastically favoring use of clickers is higher than 90 percent,” Reay said.

"In addition to this popularity, our research indicates that our sequence method of using clickers offers students a significant advantage on learning, and we are working to sharpen our methodology for measuring these learning gains. We're finding that the timing of pretests and post tests during the quarter matters, along with different applications of incentives,” he added.

During the 2006-2007 academic year, the clicker classes outperformed the non-clicker classes by an average of 10 percent -- a full letter grade -- on the multiple choice part of their final exams. The non-clicker class averaged a score of 61 percent on

this section; the clicker class averaged 72 percent.

In addition to normal testing, the physics educators gave each class a concept pretest before the quarter started, and a related post-test after the quarter was over. Then they calculated the classes' average "score gain" -- a measure of how much higher the post-test scores were compared to the pre-tests.

Both sexes had nearly equal gains in the clicker classes: females had a score gain of 6.2, and males a score gain of 6.7. In the non-clicker classes, the female score gain was 4.3, and the male score gain was 6.6.

As to why clickers seem to help female students more than male students, the anonymity of the devices may offer an advantage. In surveys, nearly all the students -- male and female -- said they liked having the ability to keep their answers private. Students can easily hold the clicker in one hand and block their neighbor's view. "We suspect that anonymity is a benefit, but right now that is really just speculation," Reay said.

In related work, Ohio State is collaborating with Chicago State University to test the effectiveness of clickers with their predominately minority student population. The Ohio State clicker questions are also being used at the College of DuPage and Wright State University.

Reay also thinks that clickers may be useful for high school classes, and his group is starting a research program with the Metro High School of Columbus, a local science and technology high school. "This research effort fits with a State of Ohio initiative to provide a seamless student transition from high school to state universities," he said.

Ultimately, the Ohio State approach could change the way classrooms use clickers -- and even change the design of clickers themselves. The physics educators are working with an Ohio clicker manufacturer, Turning Technologies, in developing a new generation of devices that will measure the student's ability to solve word and number problems rather than just multiple choice.

Among the achievements Reay is most proud of is the package of 450 sequenced clicker questions compiled with his colleagues. This package will be made available nationally to faculty teaching freshman physics, via web sites and professional meetings. Starting in 2009 they will be the first research-based

clicker materials ever offered with a textbook by publisher John Wiley and Sons, Inc.

Reay's team includes Lei Bao, associate professor of physics and director of the Ohio State Physics Education Research Group; Lin Ding, a postdoctoral researcher; Albert Lee, a doctoral student; and Pengfei Li, a former doctoral student who is now a faculty member at Savannah State University. They have collaborators at Chicago State University, the College of DuPage, Metro High School of Columbus and Wright State University.

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