Using Technology-Based Methods to Foster Learning in Large Lecture Classes: Evidence for the Pedagogic Value of Clickers

R. Mayer, A. Stull, K. Almeroth, B. Bimber, D. Chun,
M. Bulger, J. Campbell, A. Knight, and H. Zhang

University of California
Santa Barbara, CA 93106-5110

Objectives and Theoretical Framework

Today, many college courses are taught in large lecture halls that hold hundreds of students. Instructors of large lecture courses may be concerned that this learning environment can lead students to be cognitively passive. This study examines the effectiveness of a technology-supported instructional method that is intended to allow learner interactivity in a large lecture class, and thereby foster deeper learning. In particular, proponents have proposed using a personal response system (or “clickers”) in which students press a button on a hand-held remote control device corresponding to their answer to a multiple choice question projected on a screen, then see the class distribution of answers, and discuss the thinking leading to the correct answer (Duncan, 2005).

Although the personal response systems seem promising, limited research has been conducted on their effectiveness, and much of the research that been done has focused less on learning outcomes and more on how helpful the participants found the remote controls or how much they enjoyed using them (Duncan, 2005; Latessa & Mouw, 2005; Wit, 2003). Duncan (2005, p. 22) has claimed that “proper clicker use can lead to higher grades,” but offers no peer-reviewed evidence to support the claim. This project seeks to produce a methodologically sound and ecologically valid test of the pedagogic value of an instructional method based on using clickers.

It has been suggested that a personal response system, a form of instructional technology, can be used to support instructional methods that enhance cognitive activity during learning which in turn leads to better test performance (Mayer et al., 2006). This system allows students to vote on multiple-choice questions presented in class, and then in a matter of seconds see what percentage of students voted for each answer choice, which often leads to class discussion. The purpose of the current study was to empirically investigate the effects of enhanced cognitive activity on learning in a college lecture course. Based on the SOI learning theory (Mayer, 2003), we predicted that the clicker group, those who were exposed to the clickers, would outperform the no-clicker group, than those who were not exposed to clickers, on midterm and final exams in the course. The act of trying to answer sample questions then receiving immediate feedback should allow students to develop metacognitive skills for gauging how well they understood the lecture material and for how to answer exam-like questions.

Data Source

The participants were 130 college students who completed Educational Psychology (Psychology 124) during the 2004-5 academic year at the University of California, Santa Barbara in a large lecture course that did not involve technology (non-clicker group), and 107 college students who completed the same course during the 2005-6 in a large lecture course that involved technology mainly in the form of a personal response system (clicker group). All students were Psychology majors, and all were at least in their third year of college.

Methods

We used a quasi-experimental design in which we compared the combined midterm and final exam scores of students who took an educational psychology course in 2005 (non-clicker group) with those taking the same course in 2006 (clicker group). The instructor, student eligibility requirements, lecture content, reading assignments, and exam questions were identical in the two classes. The major difference between the two classes was that the clicker group received approximately 5 to 10 minutes per lecture devoted to answering and discussing 2 to 4 questions. In the clicker treatment, students press a button on a hand-held remote control device corresponding to their answer to a multiple choice question projected on a screen, see the class distribution of answers, and discuss the thinking leading to the correct answer. The time for the clicker treatment was created by providing less intense introductory coverage of some of the lecture material during each lecture.

Materials and apparatus. The materials consisted of two to four PowerPoint slides for each of 28 lectures, with each slide containing a multiple choice question that covered a portion of the lecture content. The verbatim "clicker" questions were not on the exam. The materials also consisted of a midterm exam containing 45 multiple-choice questions covering the first half of the course and a final exam containing 45 multiple-choice questions covering the second half of the course. The materials also consisted of a pre-questionnaire that solicited basic demographic information and a post-questionnaire that solicited self-reported course-related activities.

The apparatus consisted of the TurningPoint (2005) personal response system, which included 150 radio frequency (RF) response transmitters, a radio frequency (RF) receiver, a Sony Vaio laptop computer running TurningPoint and PowerPoint software. The receiver was connected to the computer through the USB port.

Procedure. During the first week of class, each student was given a transmitter for use throughout the quarter and the transmitter's identification number was registered to the student in the instructor's computer-based database. In addition, students signed a consent form that explained the study and completed the pre-questionnaire. In each lecture, after a section of the lecture, the instructor presented one or more sample multiple-choice questions on the screen. For example, a question from an early lecture on principles of learning was:

> Thorndike asked a group of students who had learned Latin and a group of students who had not taken Latin to learn a new subject such as bookkeeping. According to Thorndike's theory of transfer by identical elements, which group should learn the new subject better?
>
> (a) Students who knew Latin will learn better because Latin fosters proper habits of mind.
> (b) Students who had not taken Latin will learn better because the components in Latin conflict with the components in bookkeeping.
> (c) Both will learn the same.
> (d) The theory of transfer by identical elements does not make a prediction.

When all students had pressed a button on their response transmitters (which generally took 20 to 30 seconds), the instructor displayed a graph showing the correct answer and what percentage of students selected each answer. Then, a short discussion ensued concerning the rationale for the correct answer. Approximately, 2.5 minutes of class time was used for each question. The TurningPoint software recorded each student's response and allocated 2 points for each correct answer or 1 point for an incorrect answer. Students could earn up to 40 points in course credit for answering the "clicker questions" in class. During the last week of class, students handed in their clickers and took the post-questionnaire. The pre-questionnaire and post-questionnaire were anonymous and were linked to student performance records by code numbers rather than names.

Results and Conclusions

Does the clicker treatment improve academic performance? For each student, we tallied the number of correctly answered questions on the midterm exam (out of 45 questions) and the number of correctly answered questions on the final exam (out of 45 questions), yielding a total score (out of 90 possible). The clicker group (M = 74.9, SD = 6.9) correctly answered significantly more exam questions than did the no-clicker group (M = 72.5, SD = 6.9), $t(235) = 2.48$, $p < .05$, $d = .33$. This corresponds to a mean of 80.6% correct or a grade of B- for the non-clicker group and a mean of 83.2% correct or a grade of B for the clicker group. Overall, the clicker group showed an improvement of 2.4 more correct answers (out of a total of 90 questions) as compared to the non-clicker group, resulting in an average increase of approximately 1/3 of a grade point (i.e., from B- to B).

Does the clicker treatment improve academic performance on non-clicker related questions? Importantly, the same pattern of improvement was found for exam items that involved the same content as in clicker questions used in class (clicker-related items: $d = .29$, $t(235) = 2.19$, $p < .05$) and for exam questions that involved different content (non-clicker-related items: $d = .31$, $t(235) = 2.39$, $p < .05$). Thus, the effects of the clicker treatment cannot be attributed solely to directing the learner's attention to specific course content.

Does the clicker treatment improve student attendance? On an anonymous questionnaire given at the end of the quarter, students reported how many lectures they had missed with 1 point given for "none", 2 for "1 to 2", 2 for "3 to 5", 4 for "5 to 10," and 5 for "more than 10." Students in the clicker group ($M = 1.8$, $SD = .8$) reported missing fewer lectures than did students in the no-clicker group ($M = 2.2$, $SD = 1.1$), $d = .42$, $t(206) = 2.90$, $p < .01$. This pattern is consistent with the idea that students in the clicker group tried harder to learn than students in the no-clicker group.

Overall, these results show that instructional practices supported by educational technology can improve student academic performance in large lecture classes. In particular, educational technology can be used successfully to implement instructional methods aimed at fostering productive learning.

Educational and Scientific Significance

Concerning educational significance, this study contributes to the fledgling literature on whether or not personal response systems can be used to improve students' academic performance in an authentic classroom environment. In a quasi-experimental design, we found clear evidence that a personal response system can be used in ways that promote academic performance in large lecture classes at the college level, when it is used to stimulate student interaction concerning how to answer sample test items. If the goal is to help students learn in large college lecture classes, there is reason to consider using a personal response system to foster student engagement during class.

Concerning scientific significance, these results are consistent with the SOI theory, which proposes that it is possible to implement engaging instructional methods in large lecture classes that cause students to try harder to make sense of the material and thereby perform better on tests of learning. Our hypothesis is that the act of trying to answer sample questions and getting immediate feedback, allowed students to develop metacognitive skills for gauging how well they understood the lecture material and for how to answer exam-like questions. However, there are a number of alternative explanations that warrant further research, all based on the idea that the same method of instruction and effects on learning outcome could be accomplished without computer-based technology. For example, perhaps being exposed to questions like those on the exams could be all that is needed to help students adjust their study practices. Alternatively, being exposed to questions and required to answer them by raising their hands, could be all that is needed to motivate students to engage more deeply with the material. Finally, simply giving students points for attending the lectures--as was effectively done in the clicker class--may improve attendance, which would lead to better test scores. Further research is needed to determine which features of the clicker treatment improved student learning--seeing sample questions similar to those on the exams, answering sample questions in class, and/or receiving points for class attendance.

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