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Research Report

Effectiveness of clickers: Effect of feedback and the timing of questions on learning

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ABSTRACT

Individual response devices or "clickers" are now being used in many classrooms as an active-learning component of courses. Educators may wonder whether clickers are truly beneficial to learning. This study was designed to examine whether clickers increase retention of lecture material over two days in a more controlled situation than the live classroom. Participants watched a video lecture and were either given clicker questions about the video or no clicker questions with a 'test' occurring two days later. The effect of immediate feedback and the timing of the questions (either throughout the video or all at the end) were assessed. It was found that clicker questions improved memory for material two days later compared to no-clicker controls, provided that immediate feedback was given about each question. Scores two days later actually improved compared to scores on the day of the video when feedback was given about the correct answers. The timing of clicker questions did not affect scores. Results are consistent with studies that took place in more ecologically valid but less controlled live classroom situations. The results may guide educators in the effective use of clickers.

1. Introduction

A curious graphic has circulated on the internet in various forms lately. It shows a pyramid with various teaching methods written in segments from the top down. At the top is the lecture method and the graphic suggests that only 5% of material is retained by students 24 h after the lecture. Other methods such as use of demonstrations and participation in activities are farther down the pyramid and lead to successively higher rates of retention. We have been unable to find the source of the graphic and doubt its accuracy. But the point is made that educators must include more than straight lecture in order to help students learn.

Individual response devices or "clickers" allow students to answer review questions anonymously in class. The intention is to increase students' engagement in the classroom, act as a review for lecture material, and hopefully increase students' learning (Draper, Cargill, & Cutts, 2002; Lantz, 2010). O'Donoghue and O'Steen (2007) found that educators believe that anonymous use of clicker questions and immediate feedback will improve learning. However, two immediate drawbacks to the use of clickers in the classroom are that questions take up class time and it also takes time to prepare the questions before class. In discussions with other educators, many do not try clickers in their classrooms due to these two factors. The current study was intended to test the effectiveness of clickers to determine if the in-class time as well as the preparation is worth the time and effort.

1.1. Clicker technology

Clickers, such as those by Turning Technologies, eInstruction, and iClicker, are individual response devices held by individual students allowing them to quickly and anonymously respond to multiple choice questions presented in class. A receiver attached to a classroom computer collects and summarizes the responses instantly and projects them graphically onto the screen for students and the educator to see. Similar technology (Poll Everywhere or Top Hat) allows students to use their cellphones or tablets to make their responses (Shon & Smith, 2011). Clicker software is integrated with PowerPoint so that questions can be presented within a prepared PowerPoint presentation or spontaneously during the lecture. Although the results can be viewed immediately within the presentation software, it is also possible to save the responses in a spreadsheet, keeping a log of each student's answers for further analysis or for quiz or test taking, provided that the educator collects the identification code of the clicker and matches it to the user of each clicker. Feedback and grading of questions is immediate.

Clickers have been used at all levels of education and in a wide variety of disciplines, including Psychology, Mathematics, Biology, Chemistry, Economics, Statistics and many others. They have also

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been used in a variety of courses within these disciplines, from large introductory courses, to smaller discussion courses, to tutorials and laboratory classes.

The literature contains some discussion about technical difficulties that occasionally occur with clickers (Barnett, 2006; Dallaire, 2011; Ribbens, 2007). For example, with the Turning Point system, the USB receiver must be connected to and recognized by the computer before the Turning Point software is started. Otherwise, the responses will not be collected by the software. Barnett (2006) stated that 25% of his students thought technical difficulties detracted from the course. For educators wanting to use clickers, it is important to learn to use the system before using them in class.

1.2. Do clickers aid in learning?

Several studies have been conducted to see if clicker use will result in higher test scores than in similar classes without clickers. Flynn (2012), Freeman et al. (2007), Morling, McAuliffe, Cohen, and D'Lorenzo (2008), Poirier and Feldman (2007), Ribbens (2007), Shaffer and Collura (2009), Shapiro (2009), and Shapiro and Gordon (2012) all conducted studies comparing one class that used clickers to a similar class that did not use clickers and found that clicker use led to higher scores on exams and tests. Shapiro (2009), for example, found a 20% increase in test scores for material that was targeted with clicker questions. Not all studies showed such positive results of clickers. Karaman (2011) found that, in the first four weeks of a course, a group using clickers did better on an exam than a group that was asked the same clicker questions but were answered by individual students who raised their hands. However, in the second four weeks of the course, there were no significant differences in exam scores between groups, or in an exam given eight months after the end of the course. After clicker use, Crossgrove and Curran (2008) found that exam scores increased for a basic level biology course but not as much nor for as long in a more advanced genetics course. Tregonning, Doherty, Hornbuckle, and Dickinson (2012) found that quiz scores were higher for students using clickers immediately after the lecture but there was no difference in scores when students were retested five weeks later.

Conflicting findings within the research on clickers may in part be due to specific manipulations within each study with some of the research not simply comparing classes using clickers with classes not using clickers. For example, Karaman (2011) had one class that used clickers and a similar class that were given the same questions and response options but for each question, several students were asked to state their answer. In their experiment, clicker use after the first month was not more effective than providing the same questions as review but without the clickers. Such a result does not get at the question of clicker use versus simply continuing on with more lecture material. The use of multiple choice questions as review during a lecture may be beneficial to retention even without having all students use clickers to respond to such questions.

Many studies on the effectiveness of clickers have shown that clickers can aid in the retention of material in live classes. However, as Lantz (2010) pointed out, the use of live classes to examine clickers may be ecologically valid but introduces many potential confounding variables. Students in one class may ask more in-depth questions than the other. Holidays or snow days may mean one class has fewer lectures to attend so that the instructor must rush through or skip some material in one class but not the other. Lectures will change somewhat from one class to the next, possibly with a practice effect in which the educator becomes more effective in successive classes (Skinner, 1985). Skinner also showed that there may even be a time-of-day effect in which morning classes tend to do worse than afternoon or evening classes. The problem may be even greater if the comparison group was from a different term or year than the clicker group, as for example in Flynn (2012), Freeman et al. (2007), and Ribbens (2007). The current study will attempt to address this issue by testing the effectiveness of clickers within a more controlled laboratory situation. While not ecologically as valid as testing in live classes, several potential confounds as just described can be controlled.

1.3. Using clickers effectively

The effectiveness of clickers depends on the way they are used within the classroom; it is imperative that educators understand the mechanisms that allow clickers to work (Draper et al., 2002; Lantz, 2010; Lin, Liu, & Chu, 2011). There may be more effective ways to use clickers in class than merely sticking a few clicker questions to the beginning or end of lectures (D'Inverno, Davis, & White, 2003), or just using them to take attendance. Even studies attempting to show the effectiveness of clickers, such as Morling, McAuliffe, Cohen, and D'Lorenzo (2008) have used them only "very minimally" (p. 45). Lin et al. (2011) have suggested that clickers, if used properly, could be integrated into an effective instructional model.

The Constructivist approach to learning and memory is an information processing approach that states that learners must actively learn new material within the context of their existing knowledge base—they cannot passively absorb and store information. New information is understood in relation to familiar terms and connections between old and new information must be formed before the new information will be understood and remembered (Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Resnick, 1983). Information that is not integrated into existing knowledge bases will not be understood and is easily forgotten. Misconceptions in the relationships of information can occur when students construct incorrect relationships among ideas (Ben-Ari, 2001). The effectiveness of clickers depends on whether educators use them in ways that allow students to properly integrate course material into their existing knowledge bases. Research on the effectiveness of clickers has often not considered how clickers may help learning, so the following section considers the mechanisms with which clickers may help students learn with Constructivism as the framework.

The generation effect occurs when a student actively generates an answer to a review question and then receives immediate feedback about the question. Students who generate an answer gain an advantage on later tests compared to students that do not generate any answer and simply wait for others to supply one (Ghatala, 1981; Glisky & Rabinowitz, 1985; Hirshman & Bjork, 1988; Nairne & Widner, 1987; Slamecka & Graf, 1978; Taconnat, Foger, Sacher, & Isingrini, 2008). The generation effect occurs even if a generated answer is incorrect because misconceptions can be corrected as long as the feedback is immediate (Kornell, Hays, & Bjork, 2009; Vaughn & Rawson, 2012). Presumably, new but incorrect connections can be corrected before becoming encoded into memory.

In a traditional lecture, the instructor may ask questions at the end of the presentation of some material. Often, only a small number of students will raise their hand to answer and maybe a few others will mentally generate an answer but will not raise their hand thereby benefitting from the generation effect. Clickers increase the proportion of students who generate the answers to questions without worrying about having to justify the answer or being judged by peers (Draper et al., 2002; Wood, 2004). Yourstone, Kraye, and Albaum (2008) showed that immediate feedback using clickers was indeed effective in increasing final exam grades over students who were given the same questions as the clicker group but did not receive feedback until a future class, as usually happens with quizzes or tests. Clicker questions