

EVALUATING THE IMPACT OF STUDENT RESPONSE SYSTEMS ON STUDENT PERFORMANCE

*John P. Camey, University of Central Oklahoma
Gordon T. Gray, University of Central Oklahoma
Stacia Wert-Gray, University of Central Oklahoma*

ABSTRACT

This study explores the impact of student response systems (SRS) on student performance. The primary goal of these systems is to improve student academic achievement through the use of computerized technology in the classroom. Previous studies have provided some support for the positive impact of an SRS on learning outcomes (particularly exam scores and course grades). This research effort, comparing standardized test performance of students using an SRS with the performance of students in a more traditional learning environment, further extends the emerging stream of SRS-performance research. The study results suggest that use of an SRS in the classroom improves learning outcomes.

INTRODUCTION

The value of computerized technology in higher education has been recognized for decades (Little 1973; Peled 2000). Kryder (1999), for example, suggests use of computers at home and at school has created a more “visually literate” and collaborative generation of students. More generally, Rankin and Hoaas (2001) posit that students prefer computer facilitated education because it enhances learning outcomes by engaging more of the senses. Guthrie and Carlin (2004), focusing on interactive computer technologies, suggest that these technologies provide a good fit with the interactive learning preferred by “the rising generation of hyper-capable technology users” (p. 1).

One classroom technology emerging and gaining in popularity over the past decade is the student response system (SRS), or “clicker.” An SRS is a wireless response system allowing instructors to request information from students using interactive PowerPoint slides. Students respond through a hand-held response pad (clicker), sending information to a receiver (connected to a classroom computer). The instructor is then able to immediately share gathered information with students.

Murphy and Riddle (2003) describe a number of technologies that can be classified as a SRS. Labels for these systems (incorporating handheld devices, a receiver, and software) include classroom response systems, personal response systems, communication systems, and audience response systems (Roschelle et al. 2004; Caldwell 2007). All systems feature a handheld clicker unit with a unique signal, allowing responses from each individual student to be recorded. Classroom use varies greatly, but often involves the instructor ask-

ing questions and then presenting summaries of responses from the entire class (after all students have been given an opportunity to respond).

Although a SRS involves multiple technologies, the systems are generally considered easy to prepare and use in the classroom (Guthrie and Carlin 2004; Caldwell 2007). Many commercial systems are available and some publishers now include SRS software and support with textbook adoption. Once the software is installed, classroom use requires the instructor to create and display PowerPoint slides. A student’s task is simply to enter responses to questions by pressing clicker buttons. Student preparation for using a SRS is also quite simple. Response pads are generally inexpensive and can usually be purchased through the campus bookstore. Each student may also be required to pay a small fee to register the response pad (online) with the manufacturer. The registration process associates each student’s identifying information with a specific response pad and a particular course.

Caldwell (2007) reports that clickers have been used in a large number of classroom settings (nursing, chemistry, philosophy, business, economics, psychology, and many others), for a diversity of purposes (including “spicing up” lectures, assessing students’ opinions and understanding, and increasing instructor-student interaction), and in a variety of course formats (tutorials, lectures, peer instruction, etc.). Murphy and Riddle (2003), however, suggest that clickers are most effective in large classes as a stimulus to greater student involvement and interaction. Whatever the setting, purpose, and format, both students and instructors have generally responded positively to the systems (Elliot 2003; Beekes 2006).

As noted by Caldwell (2007, p. 13), clicker usage is

primarily motivated by the desire to improve learning outcomes. In recent years, many educators have asserted that clicker technology has tremendous potential in this regard (e.g., Johnson and McLeod 2004; Knight and Wood 2005). Long before the development of SRS technology, some educators presented evidence suggesting that feedback to students (the type now provided by clickers) is a stimulant to learning (Guthrie 1971; Kulhavy 1977; Kulik and Kulik 1988). Others noted the positive impact of repeated questioning on student performance (Frase et al. 1970; Boyd 1973). More recently, research has shown that clicker systems, through both questioning and provision of immediate feedback, are likely to increase the level of student engagement and participation during class sessions (Poulis et al. 1998; van Dijk et al. 2001). Summarizing outcomes observed in mathematics courses at West Virginia University, Caldwell (2007) suggests that this increased level of engagement positively impacts performance for many students.

Research to date offers considerable support for the suggestion that use of clickers results in improved exam scores and course grades (Duncan 2005; Knight and Wood 2005; Preszler et al. 2007). In addition to the benefits provided by increased student engagement and participation during class, potential explanations for the positive impact of clickers on learning outcomes include positive student attitudes toward clickers, frequent use of classroom discussions, and peer learning approaches along with clickers, and increased attendance (Poulis et al. 1998; Jackson and Trees 2003; Caldwell 2007). Much of the prior research examining the impact of clicker usage on learning outcomes, however, has been limited by the absence of standardized tests allowing an assessment of student understanding (or learning) given various instructional approaches (Hake 2002).

HYPOTHESES

This study seeks to add to the existing stream of research examining clicker usage and learning outcomes. Rather than seeking to replicate the results of prior studies finding positive changes in exam scores and course grades following introduction of clickers to a particular course (e.g., Preszler et al. 2007), the current study compares student learning outcomes in two class formats (same course). One class format utilizes a SRS and one does not utilize clicker technology. Student learning is assessed through performance on a standardized exam. The research effort tested two hypotheses.

H1: For each class format, student performance on an end-of-course assessment exam will exceed performance on a beginning-of-course assessment exam.

Draper (1998) argues that many applications of classroom technology (such as SRS) do not offer significant improvements over previously established delivery

methods. He further suggests that successful technology applications, rather than replacing existing approaches, address specific weaknesses of those approaches. In the case of clickers, adoption is generally seen as a means of over-coming the audience passivity and limited interaction that often develop in a traditional lecture-oriented classroom (Draper, Cargill, and Cutts 2002). Caldwell (2007) notes, however, that there are a number of ways to increase student participation, even in large classes, without adopting SRS technology (show of hands, response cards, etc.). Recognizing that positive learning outcomes are produced by a variety of delivery systems, this hypothesis suggests that the course itself, regardless of clicker usage, results in student learning.

H2: Student performance on an end-of-course assessment exam will be higher for the class format utilizing a SRS than for the class format not utilizing a SRS.

Instructive questioning is certainly not a new approach to teaching. Nor is it, more specifically, a dramatically new means of addressing audience passivity. Implementing an instructive questioning approach through a SRS, however, does offer some advantages over “low-technology” (more traditional) methods (Caldwell 2007; Draper, Cargill, and Cutts 2002). Lack of privacy with a show of hands or verbal responses, for example, may limit participation and bias student responses. A SRS not only allows private responses, but tallies responses and allows the instructor to quickly provide feedback to the class. Permanent response records are also helpful in giving instructors the capability to subsequently assess student understanding of specific material. A case can therefore be made that the SRS, though not the only means of stimulating a passive classroom, is a better means of addressing this issue than those often found in university classrooms. As Draper (1998) notes, positive classroom technology applications are characterized by a good fit between specific learning problems and the technology. Hypothesis 2 suggests that a SRS offers this type of fit, and thus has a positive impact on student learning outcomes.

METHODOLOGY

The hypotheses were tested by comparing student performance outcomes on a departmental assessment exam. Testing was completed in fundamentals of marketing class sections at a southwestern university. Each student completed the assessment exam at the beginning of the semester and at the conclusion of the semester. As shown in the Appendix, the exam contains 20 items covering basic marketing topics (market segmentation and targeting, product positioning, marketing program elements, etc.). Students select from four response options (the correct response for each item is underlined in the Appendix). Students are generally able to complete

the exam in approximately 15 to 20 minutes. At the time of this research effort, the assessment exam had been in use for several years, and was specifically designed in an effort to assess learning outcomes, program effectiveness, and instructional effectiveness.

Exam results were considered from class sections in which clickers were used and from class sections in which no SRS was utilized. Class sections met two days per week in the afternoon and were taught by the same instructor. The class time was one hour and fifteen minutes per class. Textbook, PowerPoint slides, and assignments (exams, projects, etc.) were identical for all sections. There was also little variation in classroom procedures among the sections. A lecture-discussion format, guided by PowerPoint slides, was the basic model. Video material and in-class exercises were used on a regular basis. Questions intended to stimulate discussion, assess student understanding, and clarify key points were addressed to students in all sections.

In both clicker and non-clicker sections, responses to questions were predominantly verbal. In the clicker sections, however, students used clickers in responding to a limited number of questions (generally four or five) during each regular class period. Some examples of these questions follow:

- ◆ What is the BCG term for a business unit that has a relatively high market share in a relatively slow growing market?
- ◆ Purchase of a soft drink would generally represent which type of consumer problem solving?
- ◆ What do we call those forces that the organization's marketing department cannot control?

For each question, four response options were available to students. Identical questions were presented (either verbally or through PowerPoint slides) to students in the non-clicker sections. No questions presented in the classroom (including those utilizing the SRS) were included in the departmental assessment exam.

The instructor had utilized clickers in previous classes and reported little difficulty in again preparing classes for clicker use. A few students (less than ten) in the clicker sections had purchased and used clickers previously and were able to use their clickers in the fundamentals of marketing course. The remaining students purchased clickers at the campus bookstore for \$15. All students in the clicker sections were required to pay an additional \$15 to register a clicker online for semester use (one clicker can be used in all courses). No students reported difficulties in purchasing or registering clickers. Possibly due to many students lack of prior exposure to SRS technology, however, the instructor was required to address several minor problems with clicker use in the first two class meetings. After these initial difficulties, students did not present the instructor with either general or specific concerns related to classroom use of the SRS. At

the conclusion of the semester, many students in the clicker sections provided positive verbal feedback to the instructor regarding clicker usage.

Preliminary analyses suggested that the composition of the clicker and non-clicker sections was very similar. Chi-square analyses indicated no significant differences between the two groups in terms of sex, classification (junior or senior), major, or status as a domestic or international student. A two independent sample t-test found no significant difference in mean student age between the clicker and non-clicker sections.

RESULTS

All performance comparisons were completed using independent samples t-tests. Student performance outcomes were first examined by comparing mean scores on the beginning-of-course assessment exam with mean scores on the end-of-course assessment exam. This analysis was completed (separately) for the class format (sections) in which clickers were used and for the class format (sections) in which clickers were not used. Levene's test indicated that equality of variances could be assumed for the two groups in each comparison. In both cases, mean exam scores were significantly higher on the end-of-course assessment exam. These results, displayed in Table 1, support H1.

The beginning-of-course assessment mean exam score for the clicker class sections was then compared with the beginning-of-course mean exam score for the non-clicker sections. Levene's test again indicated that equality of variances could be assumed for the two groups. The test result, shown in Table 2, indicated no significant difference in beginning-of-course scores between the two class format groups. This suggests that students in the clicker sections of the basic marketing course were similar to students in the non-clicker sections in terms of initial knowledge of the course material.

The final comparison was between end-of-course mean exam scores for the two groups. Levene's test indicated that equality of variances could not be assumed for the two groups ($F = 2.82, p = .10$), and an adjusted t-test was therefore used in the analysis. This test revealed that the mean exam score was significantly higher for class sections in which a SRS was used. The test result, presented in Table 3, supports H2.

DISCUSSION

The results of this research provide evidence that student learning occurs through both a traditional classroom format (lecture and discussion) and a classroom format utilizing SRS technology. The evidence also suggests that use of a SRS positively impacts student learning (or performance) when compared with the more traditional class format. These findings are consistent

TABLE 1 COMPARISON OF BEGINNING AND END OF COURSE EXAM SCORES					
	N	Mean	SD	t	p-value
Non-Clicker					
Beginning	61	7.82	2.68	6.72	<.001
Ending	60	11.68	3.58		
Clicker					
Beginning	53	6.98	4.13	9.93	<.001
Ending	58	13.67	2.92		

TABLE 2 COMPARISON OF BEGINNING OF COURSE EXAM SCORES					
	N	Mean	SD	t	p-value
Non-Clicker	61	7.82	2.68	1.30	.20
Clicker	53	6.98	4.13		

TABLE 3 COMPARISON OF END OF COURSE EXAM SCORES					
	N	Mean	SD	t	p-value
Non-Clicker	60	11.68	3.58	3.31	.001
Clicker	58	13.67	2.92		

with previous research findings pointing to improvements in exam scores and grades through clicker usage (Knight and Wood 2005; Caldwell 2007). The research also extends previous efforts, while addressing a limitation of prior studies, by considering student performance on standardized tests rather than evaluating learning outcomes using only in-class assessment instruments. In responding to the call for more systematic research examining the learning benefits of clickers (Hake 2002; Roschelle et al. 2004), this study helps to build a foundation for future research.

A limitation of the study is the inability to precisely identify what causes improved student performance when clickers are used in the classroom. As Roschelle et al. (2004) note, changes to teaching approaches and classroom procedures, rather than the use of a SRS, may be

responsible for positive learning outcomes. Caldwell (2007) further suggests that students may be treated differently when clickers are used and this special treatment (even if more perceived than actual) could be a key factor causing performance improvements. While these points are certainly valid, it must also be pointed out that improved teaching methods and “special treatment” given to students using clickers both come about as a result of clicker usage. In a sense, clickers may positively impact learning outcomes both directly and indirectly. A higher level of student engagement, stimulated by repeated questioning and immediate feedback, aids in retention and has a direct and positive impact on student performance. But in a more indirect manner, a SRS may improve learning outcomes by helping to create positive student affect, contributing to increased attendance, and

spurring classroom management changes. In all cases, the underlying stimulus for the improved performance outcomes is clicker usage.

This study examines learning outcomes among a limited number of students completing one course at one university. Any attempt to generalize the results to other learning environments is certainly open to debate. From this perspective, the study can be viewed as an exploratory effort. It is hoped that this research, as well as other efforts, will help in further developing a stream of research examining the learning (or performance) impact of clicker use in different environments. Results from a small number of prior studies have already led some to conclude that the positive learning impact of clickers is limited to particular courses (e.g., Slain et al. 2004). Other studies, however, report improved student perfor-

mance across a variety of courses (e.g., Preszler et al. 2007). Caldwell (2007), in her extensive review of clicker usage in higher education, suggests that combining peer learning with clickers seems to improve learning outcomes to a greater extent than simply integrating clickers into traditional lecture class formats. Preszler et al. (2007), exploring another aspect of SRS technology integration, find evidence of differences among upper-division and lower-division students both in their general impression of clickers as well as learning outcomes. These and other research efforts attest to the need for future research examining clicker usage in many courses and course formats. More specifically, course subject, the manner of clicker integration, and student status (in terms of program/degree completion) appear to be particularly promising areas for extended research efforts.

REFERENCES

- Beekes, W. (2006), "The 'Millionaire' Method for Encouraging Participation," *Active Learning Higher Education*, 7 (1), 25–36.
- Boyd, W. (1973), "Repeating Questions in Prose Learning," *Journal of Educational Psychology*, 64, 31–38.
- Caldwell, J.E. (2007), "Clickers in the Large Classroom: Current Research and Best Practices Tips," *CBA-Life Sciences Education*, 6 (Spring), 9–20.
- Draper, S. (1998), "Niche-Based Success in CAL," *Computers and Education*, 30, 5–8.
- _____, J. Cargill, and Q. Cutts (2002), "Electronically Enhanced Classroom Interaction," *Australian Journal of Educational Technology*, 18 (1), 13–23.
- Duncan, D. (2005), *Clickers in the Classroom: How to Enhance Science Teaching Using Classroom Response Systems*. New York: Addison Wesley and Benjamin Cummings.
- Elliot, C. (2003), "Using a Personal Response System in Economics Teaching," *International Review of Economics Education*, 1 (1), 80–86.
- Frase, L., E. Patrick, and H. Schumer (1970), "Effect of Question Position and Frequency Upon Learning from Text Under Different Levels of Incentive," *Journal of Educational Psychology*, 61, 52–56.
- Guthrie, J. (1971), "Feedback and Sentence Learning," *Journal of Verbal Learning and Verbal Behavior*, 10, 23–28.
- Guthrie, R.W. and A. Carlin (2004), "Waking the Dead: Using Interactive Technology to Engage Passive Listeners in the Classroom," *Proceedings of the Tenth Americas Conference on Information Systems*, New York, (August), 1–8.
- Hake, R. (2002), "Lessons from the Physics Education Reform Effort," *Conservative Ecology*, 5 (2), 28.
- Jackson, M. and A. Trees (2003), *Clicker Implementation and Assessment*. Retrieved from [comm.colorado.edu/mjackson/clickerreport.htm].
- Johnson, D. and S. McLeod (2004), "Get Answers: Using Student Response Systems to See Students' Thinking," *Learn. Lead. Technology*, 32 (4), 15–23.
- Knight, J. and W.B. Wood (2005), "Teaching More by Lecturing Less," *Cellular Biology*, 4, 298–310.
- Kryder, L. (1999), "Integrating Computer Literacy: Why and What Can Be Done," *Business Communication Quarterly*, 62 (2), 81–86.
- Kulhavy, R. (1977), "Feedback in Written Instruction," *Review of Educational Research*, 53, 211–32.
- Kulik, J. and C. Kulik (1988), "Timing of Feedback and Verbal Learning," *Review of Educational Research*, 58, 79–97.
- Little, J. (1973), "The Role of Academic Computer Department in the Uses of Computer in the Undergraduate Curricula at the Two-Year College Level," *Paper presented at the Fourth Conference on Computers in the Undergraduate Curricula*. Claremore, CA.
- Murphy, P. and R. Riddle (2003), *Interactive Learning Tools and Techniques: Personal Response Systems*. Retrieved from Duke University Center for Instructional Technology: [http://cit.duke.edu/resource-guides/personal%20Response%20Systems.pdf], (2004, February 16).
- Peled, A. (2000), "Bringing the Internet and Multimedia Revolution to the Classroom," *Campus Wide Information Systems*, 17 (1), 16.
- Poulis, J., C. Massen, E. Robens, and M. Gilbert (1998), "Physics Lecturing with Audience Paced Feedback," *American Journal of Physics*, 66 (5), 439–41.
- Preszler, R.W., A. Dawe, C.B. Shuster, and M. Shuster (2007), "Assessment of the Effects of Student Re-

- sponse Systems on Student Learning and Attitudes Over a Broad Range of Biology Courses,” *CBE-Life Sciences Education*, 6 (Spring), 29–41.
- Rankin, E., and D.J. Hoass (2001), “Teaching Note: Does the Use of Computer Generated Slide Presentations in the Classroom Affect Student Performance and Interest?” *Eastern Economic Journal*, 27 (3), 355.
- Roschelle, J., W. Penuel, and L. Abrahamson (2004), “The Networked Classroom,” *Educational Leadership*, 61 (5), 50–54.
- Slain, D., M. Abate, B.M. Hodges, M.K. Stamatakis, and S. Wolak (2004), “An Interactive Response System to Promote Active Learning in the Doctor of Pharmacy Curriculum,” *American Journal of Pharmaceutical Education*, 68, 1–9.
- van Dijk, L., G. van den Ber, and H. van Keulen (2001), “Interactive Lectures in Engineering Education,” *European Journal of English Education*, 26 (1), 15–18.

APPENDIX ASSESSMENT EXAM

1. Environmental scanning is the process of continually acquiring information on events occurring outside the organization in order to identify and interpret potential trends.
2. A group of potential consumers toward which an organization directs its marketing program is a target market.
3. A competitive advantage is a unique strength that an organization has relative to its competitors.
4. If Kellogg issues a coupon for \$1.00 off the next purchase of Corn Flakes and places that coupon inside a box of Corn Flakes, the company is implementing a market penetration strategy.
5. Market segmentation involves aggregating prospective buyers into groups that (1) have common needs and (2) will respond similarly to a marketing action.
6. Jakubowski Farms Gourmet Bread Base is the brand name for a mix designed for use in bread machines. The mixes, only available through the mail, are sold in 2-pound canisters for \$14.99 plus shipping. People learn about this product through word-of-mouth communication and through bread machine demonstrations the company’s founder offers to civic and community groups in Wisconsin. This is a description of the company’s marketing mix.
7. A skimming price strategy involves setting a high initial price for a product and assuming that a limited number of customers with a strong desire for the product will be willing to pay that price.
8. Steve Walker was happy with his newly purchased personal computer. It had all the features he wanted and he considered the \$1800 price to be reasonable. As he was taking the computer out of the box, Walker noticed an advertisement in the local paper showing a similar computer system for only \$1500. Suddenly, Walker began to doubt his purchase decision. He was afraid that he had not gotten such a good deal after all. Steve Walker was experiencing cognitive dissonance.
9. Consumers generally spend little time and effort evaluating alternatives in the purchase products such as soap and milk. The purchase process for such items, termed routine problem solving, is virtually a habit and is typical of low-involvement decision-making.
10. Manufacturers, retailers, and government agencies that buy goods and services for their own use or for resale are collectively referred to as the organizational market.
11. To lower costs and reduce manufacturing time, Michelin has people work together on important purchases. This type of cross-functional group, including individuals in various roles (buyers, decision makers, gatekeepers, etc.) is known as a buying center.
12. A concept describing the stages a product passes through in the marketplace – introduction, growth, maturity, and decline – is called the product life cycle.

APPENDIX (CONTINUED)
ASSESSMENT EXAM

13. Harry & David is a catalog retailer. At its inception, the company sold fruit baskets and popularized the “Fruit of the Month” concept. The company later abandoned this restrictive definition of itself, expanded its product mix, and used promotion to explain that it is now the source of the “perfect gift” for every occasion. Harry & David used a repositioning strategy.
14. The individuals and firms involved in the process of making a good or service available for use or consumption are considered members of a marketing channel.
15. A dual distribution approach allows a firm to reach different groups of buyers by employing two or more types of channels for the same basic product.
16. The process of defining a marketing problem and/or opportunity, systematically collecting and analyzing information, and then recommending actions to improve an organization’s marketing activities is called marketing research.
17. Consumer oriented is an appropriate term for the marketing concept era.
18. In the 1960’s, Pillsbury defined its mission as, “We are in the business of satisfying needs and wants of customers.” This brief statement has come to be known as the marketing concept.
19. Several states have legislation requiring children under four to use car seats. This type of influence on marketing decision making is known as an external factor.
20. A market is comprised of people with the desire and the ability to buy a product.