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Clickers in the Classroom: A Review and a Replication

Shawn M. Keough[1]

Abstract

This article reviews 66 clicker technology–based studies focusing on student perceptions/outcomes. Eight major perceptions/outcomes are noted, including high levels of performance (actual and perceived), student attention span, attendance, and participation, as well as student perceptions of satisfaction, feedback, and ease of use. Because the review revealed that studies involving clickers within the management discipline were nonexistent, an empirical study was conducted to determine whether the perceptions/outcomes of clickers realized in other disciplines could be duplicated in the management discipline. The results of the empirical study indicate that the same perceptions/outcomes can be attained within the management discipline.

Keywords

clickers, ease of use, attendance, attention span, participation, academic performance, satisfaction, feedback

The use of clickers in the classroom has gained popularity within the academic environment over the past two decades. The majority of early clicker research occurred within the medical/health professions and the natural sciences because these disciplines were early adopters of clicker technology. More recently, the study of clicker use has begun to emerge from a variety of other

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academic disciplines. The increase of interest in clicker technology by researchers stems from the benefits provided by clicker use, including instantaneous feedback of student understanding (Barnett, 2006; Crossgrove & Curran, 2008; Lincoln, 2008), increases in student performance (Caldwell, 2007; El-Rady, 2006; Ueltschy, 2001), attendance (Caldwell, 2007; Koenig, 2010; Lincoln, 2008), attention (Crossgrove & Curran, 2008; Lincoln, 2008; Prather & Brissenden, 2009), and participation (Addison, Wright, & Milner, 2009; Salemi, 2009; Sprague & Dahl, 2010).

The benefits clickers contribute to classroom learning environments have been well documented for some academic disciplines. However, widespread acceptance and use of clickers in other disciplines, specifically management, has not been noted in the literature. Therefore, this article provides a review of existing clicker use research and presents a replication of that research using students in an upper-level management class.

Clicker Technology Overview

A number of terms are used to describe clickers, including *classroom response systems* (Salemi, 2009; Suchman, Uchiyama, Smith, & Bender, 2006), *personal response systems* (Beekes, 2006, Knight & Wood, 2005), *group response systems* (Carnaghan & Webb, 2007), *student response systems* (Cunningham, 2008; Trees & Jackson, 2007), *electronic response systems* (Hatch, Murray, & Moore, 2005; Ghosh & Renna, 2009), *personal response units* (Barnett, 2006), *audience response systems* (Caldwell, 2007; Johnson, 2005), *electronic classroom voting systems* (El-Rady, 2006), *classroom performance systems* (Blackman, Dooley, Kuchinski, & Chapman, 2002; Petersohn, 2008), *wireless course feedback systems* (Rice & Bunz, 2006), *audience response technology* (MacGeorge et al., 2008; Stein, Challman, & Brueckner, 2006), *electronic student response technology* (Greer & Heaney, 2004), *classroom communication systems* (Nicol & Boyle, 2003; Paschal, 2002), *interactive technology* (Eastman, Iyer, & Eastman, 2011; Ueltschy, 2001), *electronic voting systems* (Stuart, Brown, & Draper, 2004), and *voting machines* (Reay, Bao, Li, Warnakulasooriya, & Baugh, 2005). Although a wide variety of terms have been used to describe clickers, the modern clicker systems available are remarkably similar.

Clicker systems have evolved from expensive, hard-wired systems that were specific to one location to inexpensive wireless and portable systems that can be used in a variety of locations. Current clicker systems generally consist of student transmitters, an instructor receiver, and a computer. The student transmitters, usually small handheld units approximately the size of a

cell phone, are used by students to send question responses via a keypad to the instructor receiver. The instructor receiver acquires the transmitted student responses and sends those responses to a regular desktop or laptop computer for real-time processing, allowing instructors to view how the questions were answered. Questions can require simple true/false or yes/no answers, multiple-choice responses, or even short answers depending on the specific system employed. Barber and Njus (2007) provide an excellent review of six clicker systems, pointing out strengths and weaknesses of each system.

From an instructor perspective, one of the greatest benefits resulting from the use of clickers is the ability of the system to relay instantaneous feedback concerning student understanding of material presented (Nelson & Hauck, 2008; Stuart et al., 2004; Yourstone, Kraye, & Albaum, 2008). Instructors can present course material and then require students to answer questions based on the material presented via the clickers. Unlike traditional question/answer sessions where only one or two students have the opportunity to voice an answer, every student in the class can answer the question. Additionally, the question is graded instantaneously and the instructor can see whether or not the class understands the material before moving on to new material. The benefit of instantaneous feedback on student understanding alone should serve as an incentive for instructors to consider adopting clicker technology. However, research indicates that clickers provide more than just instantaneous feedback for instructors as is illustrated in the following section.

Clicker Use Literature

To provide an extensive, but not overwhelming, review of studies involving clicker use in the classroom, this review focused on articles published in journals across multiple disciplines over the past 15 years. This limited timeframe was chosen due to the significant changes in clicker technology from more individualized to standardized systems (Judson & Sawada, 2002). Library databases, including ABI/INFORM Global and ProQuest, were accessed to conduct searches for clicker studies using the aforesaid terms describing clickers in the "Clicker Technology Overview" section of this article. Note that this review is limited to empirical studies focusing on student perceptions/outcomes related to clicker use. Studies related to instructor adoption, recommendations for use, or instructor attitudes toward clickers were not considered.

In all, 66 studies (see the appendix) were identified across 16 specific disciplines (see Table 1). Not surprisingly, the majority of articles resided within the hard sciences disciplines, specifically the biological (14), physical (12), and medical (11) sciences providing support to observations made by

Table 1. Summary of Study Disciplines/Samples

Discipline	# Studies	# Samples
Biological sciences	14	17
Physical sciences	12	13
Medical/nursing	11	11
Marketing	4	6
Library instruction	4	4
Psychology	4	4
Accounting	3	4
Communications	3	3
Economics	3	3
Dentistry	1	1
Law	1	1
MIS	1	1
Operations management	1	1
Philosophy	1	1
Political science	1	1
Sociology	1	1
Unknown	1	1
Total number of studies/samples	66	73

Lincoln (2009) regarding the concentration of clicker use within the hard sciences. Other disciplines, as noted in Table 1, have limited representation in the body of literature with the number of studies in each noted discipline ranging from one to four. Note that the number of discipline-related studies (66) and number of samples (73) differ. This difference was due to the inclusion of multiple samples in some studies.

Within the 66 studies, 8 general student perceptions/outcomes were noted: actual performance, satisfaction, perceived performance, attention span, attendance, participation, feedback, and ease of use. A summary of how many studies focused on each outcome is given in Table 2.

Previous Study Criteria of Clicker Use

A number of criteria have been investigated regarding clicker use, and the methods used to obtain outcome data differ between studies. Some studies employ student surveys with Likert-type scale questions and open-ended questions whereas others rely on objective measures such as actual grades

Table 2. Summary of Study Criteria

Criterion	Number of Samples	Significant Positive Outcomes
Actual performance	34	22
Satisfaction	47	46
Perceived performance	37	35
Attention span	25	23
Attendance	24	19(7)
Participation	21	20
Feedback	15	15
Ease of use	8	8

Note: Most studies focused on multiple outcomes.

and instructor-maintained attendance records. The following sections summarize the findings of each study and the type of measurement used. Because actual performance (grades) was the only criterion measured objectively across all studies including it, actual performance is discussed first. The remaining criteria are discussed in order of the most to least studied.

Actual performance. Thirty-one studies with a total of 34 samples examined objective measures of performance as an outcome of clicker use. Objective measures included exam scores, quiz scores, final grades, scores on pre- and posttests, mean pass rates, and standardized tests. With the exception of one study using pre- and posttest comparisons (Trapskin, Smith, Armitstead, & Davis, 2005), comparisons of these measures were made between students in classes using clickers versus students in classes not using clickers. The non–clicker classes used for comparison were equivalent courses that were taught concurrently with the clicker-use classes (16 samples) or in prior semesters (17 samples). Twenty-two of the samples reported significant increases in student performance when clickers were used. Of the 12 samples not finding significant increases in performance, 10 studies found that students using clickers did perform at higher levels than students not using clickers. However, those increased levels were not statistically significant. One study (Chan & Knight 2010) found a significant decrease in performance by clicker users compared with non–clicker users. Overall, the findings indicate significant increases in performance when clickers are in use.

Satisfaction. Forty-two studies with a total of 47 samples examined student satisfaction with clickers. Forty-six of the samples indicated high levels of student satisfaction with the use of clickers. Thirty-eight of the samples

measured satisfaction using Likert-type scale questions asking whether the clickers were fun to use or whether they thought clickers should continue to be used in future classes. Nine of the samples noted a high number of responses to open-ended questions, which indicated the students felt a high level of satisfaction with the clickers. Overall, the findings indicate students experience high levels of satisfaction when clickers are used.

Perceived performance. Thirty-three studies with a total of 37 samples examined student perceptions of class performance as an outcome of clicker use. Thirty-five of the samples indicated high levels of perceived performance by students. Likert-type scale questions such as "[Using a CPS] Improved my performance in class" (Ghosh & Renna, 2009) and "The use of clickers improved my performance in the course" (Nelson & Hauck, 2008) were used to measure perceived performance. Overall, the findings indicate students perceive that the use of clickers increases their performance.

Attention span. Twenty-three studies with a total of 25 samples examined attention span as an outcome of clicker use. Of the 25 samples, 23 found that classes using clickers had high levels of student attention span. A majority of the samples (20) measured attention span with Likert-type scale questions such as "The student response system helped focus the class as a whole on the subject" (Cunningham, 2008) and "The iClicker questions helped me to focus and pay more attention in lectures" (Addison et al., 2009). The remaining five samples noted a high number of responses to open-ended questions such as "What were the strengths of using clickers in the classroom?" (Patterson, Kilpatrick, & Woebkenberg, 2010), which indicated the students felt the clickers increased their attention span. Overall, the findings seem to provide strong evidence for contributing to student attention span.

Attendance. Twenty-four studies examined attendance as an outcome of clicker use. Of these 24 studies, 19 found that classes using clickers had high levels of student attendance. These findings seem to provide strong support for increases in attendance. However, several factors other than the simple use of clickers may have affected the findings. First, attendance in a number of studies (10) was measured by students providing a self-report. It is possible that a significant difference between the attendance reported and the actual attendance occurred. Second, in 7 studies, the use of clickers was tied directly to the students' grade. Thus, some students may have attended class simply to receive the points involved with the clicker use, not because of the clicker per se. Two studies used both a self-report of attendance and points for attendance. After removing these studies for potential bias, only 9 studies remained. Of these 9 studies, 7 found significant increases in attendance when clickers were used as compared with attendance rates in similar classes without clicker use.

Participation. Nineteen studies with a total of 21 samples examined participation as an outcome of clicker use. For all the studies, simply using the clickers was not considered participation. Instead, participation was considered as student engagement or focus on the content and discussion. Twenty of the samples indicated high levels of student participation as a result of clicker use. Fourteen of the samples measured perceived participation using Likert-type scale questions such as "The clickers did not increase my participation in class" (Crossgrove & Curran, 2008) and "I participated more in this class because I was using a clicker" (Sprague & Dahl, 2010). Three samples noted a high number of responses to open-ended questions, which indicated the students felt clickers increased participation. Two samples indicated observed increases in participation but provided no quantitative support. Two samples tracked student participation using the number of responses provided by the student transmitters for each question. One study (Carnaghan & Webb, 2007) tracked the number of questions answered and asked by students using clickers versus student not using clickers. Instead of finding an increase in participation, Carnaghan and Webb (2007) found participation actually decreased, especially when most students answered the questions correctly. With this one exception, the findings indicate high levels of student participation when clickers are in use.

Feedback. Twelve studies with a total of 15 samples examined the aspect of feedback as a benefit of clicker use. Ten of the samples measured the level of feedback obtained using Likert-type scale questions such as "Clickers helped me get instant feedback on what I knew and didn't know" (Crossgrove & Curran, 2008). The other five samples noted a high number of responses to open-ended questions, which indicated the students felt the clickers provided a high level of feedback. Overall, the findings indicate students perceive that clickers provide a high level of feedback.

Ease of use. Eight studies examined student perceptions of clicker ease of use. All eight studies found that students considered clickers to be easy to use. All eight studies measured ease of use using Likert-type scale questions such as "The PRS is easy to use" (Beekes, 2006; Elliott, 2003) and "Using the technology is easy" (Fitch, 2004). Overall, the findings indicate that students find clickers easy to use.

Clicker Technology in Management Classes

Given the nature of the benefits noted from its use, the adoption of clicker technology appears to make sense for general use across all disciplines of higher education. However, as cautioned by Davis (1989), unwillingness on

the part of the end user to make appropriate use of technology can negate the potential benefits. Thus, it becomes important to understand student perception of clicker technology in the classroom. Equally important is the need to understand student perceptions of clicker technology across disciplines because student mindsets and thought processes differ from discipline to discipline.

As noted earlier, and illustrated by the lack of management studies in the previous literature review, the study of clicker benefits has been overlooked by the discipline of management. In an effort to fill this gap in the literature, an empirical study was performed to determine if the benefits of clickers noted in other disciplines were transferrable to the management discipline. Using the findings of the previous literature review as support, the following hypotheses were formulated regarding clicker use in a management setting:

Hypothesis 1: Higher levels of academic performance on exams will be exhibited by students using clickers in a management setting than students not using clickers.

Hypothesis 2: High levels of satisfaction with clickers will be experienced by students exposed to clickers in a management setting.

Hypothesis 3: High levels of perceived increases in performance will be attributed to the use of clickers by students using clickers in a management setting.

Hypothesis 4: High levels of participation will be experienced by students exposed to clickers in a management setting.

Hypothesis 5: High levels of feedback will be perceived by students exposed to clickers in a management setting.

Hypothesis 6: High levels of ease of use will be perceived by students exposed to clickers in a management setting.

Methodology

Technology Used

The clicker technology chosen for use in this study was the ResponseCard XR by Turning Technologies. This particular system included individual handheld, radio frequency (RF) wireless keypads for student use, and a USB RF receiver that was plugged into the existing classroom computers. The Turning Point "Poll in PowerPoint®" software was downloaded from the Turning Technologies website and used to embed questions directly onto lecture slides in PowerPoint by the instructor. The computer/projector equipment

Table 3. Student Information by Class Section

	Number of Students	Male	Female	Student Classification
Clicker section	49	29 (59%)	20 (41%)	17 (34.7%)—Senior 32 (65.3%)—Junior
Non–clicker section	45	25 (56%)	20 (44%)	19 (42.2%)—Senior 26 (57.8%)—Junior

in the classroom was used to project the PowerPoint slides for viewing by the class. The RF wireless keypads were purchased by the department and made available to students at no cost.

Participants

College students ($n = 94$) attending a public university in the southern United States were participants in this study. Participants included students enrolled in two concurrent sections of an upper-level management class ($n = 49$, $n = 45$) taught by the same instructor. Students in one section made use of the clicker technology for the second half of the semester (clicker group). Students in the other section were only exposed to the clicker technology on the last day of the semester (non–clicker group). The breakdown of the two class sections is shown on Table 3. None of the students involved in the study had prior experience with the clicker technology.

Procedure

The original intent of the study was to expose one class to the clicker technology for the entire semester, but the clickers were not delivered prior to the beginning of the semester. However, the delay in the delivery of the clickers allowed a good section-to-section comparison to serve as a baseline of academic capability between the two sections. For the first half of the semester, both sections were exposed to only traditional methods of teaching including standard lectures with the use of PowerPoint. After two exams, the clicker section was introduced to the clicker technology, and each student was given a wireless keypad for use. The clicker technology was then used throughout the rest of the semester to answer in-class questions presented during lectures. A minimum of four questions requiring clicker responses were asked during each lecture. Although other question types were available, the instructor only

used multiple-choice and true/false questions for the study. Questions were embedded into PowerPoint lecture slides displayed on a projection screen. When a PowerPoint slide with a question appeared, students were given 1 minute to answer the question using their clicker. The correct answer was then provided to the class. Because student responses were tallied instantly, the instructor was able to determine how many students answered the question correctly/incorrectly. If more than 25% of the class answered the question incorrectly, the instructor spent a little more time explaining the concept. For the non–clicker section, the same questions were displayed and students were asked to answer the questions verbally. Several students were then called on to provide verbal answers. If it appeared that students were uncertain of the answer or simply guessing, a little more time was spent explaining the topic.

At the end of the semester, the non–clicker section was introduced to the clicker technology and allowed to use the clickers while listening to a non-course-related presentation. Immediately after the exposure to the clickers, the non–clicker section was asked to complete a clicker opinion survey that measured ease of use, usefulness, cost considerations, and general opinions of the clicker technology. The clicker section was asked to complete a similar clicker opinion survey at the end of the semester.

Measures

Academic performance was measured by actual grades earned on four exams administered throughout the semester. Satisfaction was measured using the following 7-point Likert-type scale statement: "I would like to see clickers used more widely in business classes." Perceived increases in performance were measured using the following 7-point Likert-type scale statements: "Using the clicker improves my performance" and "Using the clickers helped me do better in this class." The effect of clickers on participation was measured using the following 7-point Likert-type scale statement: "I was more likely to respond/participate/engage with the content because of the clickers." Feedback was measured using the following 7-point Likert-type scale statement: "Using the clickers helped highlight concepts/content areas I needed to study more." Ease of use was measured using an adapted five-item scale by Davis (1989). Each item was rated on a 7-point Likert-type scale with the range of (1) *strongly disagree* to (7) *strongly agree*. Thus, a higher score indicated a higher perceived ease of use. To capture some qualitative data, two open-ended questions were asked: "What are some weaknesses/disadvantages with using the clickers?" and "What are some strengths/advantages with using the clickers?"

Table 4. Mean Scores on Examinations

	Clicker Section	Non–Clicker Section	*p*
Exam 1	87.92%	84.39%	.64
Exam 2	86.09%	82.18%	.27
Exam 3	87.67%	83.24%	.05
Exam 4	90.53%	84.51%	<.01

Because some of the surveys were not completely filled out by the students, a total of 89 surveys of the 94 distributed were useable. Forty-nine surveys were useable for the clicker section, and 40 surveys for the non–clicker section were useable. For the two open-ended questions, the total number of itemized comments from the clicker section regarding strengths was 61, and the total number of itemized comments regarding weaknesses was 38. The total number of itemized comments from the non–clicker section regarding strengths was 12, and the total number of itemized comments regarding weaknesses was 12.

Results

Academic Performance

Hypothesis 1 posited that students using clicker technology would exhibit higher academic performance than those students not using clicker technology. This hypothesis was tested by comparing the exam scores of the clicker section with the non–clicker section. As noted earlier, the first two exams for both sections had exposure to the same type of learning environment whereas the last two exams reflect the introduction of clickers in one section.

Table 4 indicates that for the first two exams, no significant difference in academic performance as indicated by exam scores existed between the two sections for Exam 1 ($F = .22$, $p = .64$) or Exam 2 ($F = 1.22$, $p = .27$). Thus, it appeared that the level of academic ability was similar between the two sections. However, after the introduction of the clickers, a significant difference was noted for Exam 3 ($F = 3.94$, $p = .05$) and Exam 4 ($F = 11.80$, $p < .01$) between the two sections. Thus, Hypothesis 1 is supported.

Other Criterion

Statistical analyses for satisfaction, perceived performance, participation, perceived feedback, and perceived ease of use were conducted using *t* tests

Table 5. Hypotheses 2 to 6: Midpoint Comparison Results

Criterion	Scale Midpoint	Criterion Mean	*t* Value (n = 49)	p	Outcome
Satisfaction	4.0	5.98	10.18	<.001	Hypothesis 2 supported
Perceived performance	4.0	5.47	8.36	<.001	Hypothesis 3 supported
Participation	4.0	6.14	11.92	<.001	Hypothesis 4 supported
Perceived feedback	4.0	5.69	8.64	<.001	Hypothesis 5 supported
Perceived ease of use[a]	4.0	6.20	20.19	<.001	Hypothesis 6 supported

a. Internal reliability test, Cronbach's α = .80.

that compared the average student response with the midpoint of the Likert-type scale (i.e., 4.0). A significant difference between the midpoint and the mean student response for a particular criterion would indicate that the mean student response was significantly different than a neutral response. Table 5 provides the results of the midpoint comparisons.

As can be seen in Table 5, the results of the midpoint comparisons indicate that each criterion mean was significantly greater than the midpoint ($p < .001$). Thus, Hypotheses 2, 3, 4, 5, and 6 are supported.

Open Questions Concerning Strengths/Weaknesses

The majority of comments targeting the strengths of the clicker technology reinforced the benefits found in previous studies regarding increased participation, attention, the anonymous nature of answering questions, instantaneous feedback for students and the instructor, and general enjoyment of learning. A few comments focused on ease of use and the ability to take attendance. Table 6 summarizes the strength comments.

The majority of comments about potential weaknesses of the clicker technology revolved around an intermittent problem with the handheld units. Throughout the semester, a few handheld units per class period would experience problems acquiring the appropriate RF channel, rendering the unit incapable of responding to questions. To fix the problem, the battery panel of the

Table 6. Student Comments on Clicker Strengths

	Number of Responses	
	Clicker Section	Non–Clicker Section
Increases participation in class	14	6
Reinforces understanding of information presented	13	1
Improves attention in class	9	0
Anonymous, no fear of embarrassment	6	1
Allows student instant feedback on comprehension	5	0
Makes learning more fun/interesting	4	0
Allows instructor instant feedback on student comprehension	3	1
Easy to use	3	1
Helps promote class discussion	3	0
Can take attendance	1	1
Helps reduce paper usage, environmentally friendly	0	1
Total comments	61	12

unit needed to be opened, and the battery had to be removed and reinserted. The unit would then usually acquire the appropriate RF channel and be ready for use. The whole process took less than a minute but was a source of frustration for students. Some other concerns included fear of losing the clicker, forgetting to bring the clicker to class, and costs involved with the clicker technology. Table 7 summarizes the weakness comments.

Discussion

The results of this study clearly indicate that students exposed to clickers in a management setting find the technology easy to use whether they have been exposed to clickers for a short demonstration or over a long period of time. Although many types of technology require a steep learning curve by users, clicker technology does not suffer from this problem on the student side. However, it should be noted that the learning curve for instructors can be considerable (Hatch et al., 2005; Lincoln, 2009; Sprague & Dahl, 2010).

The results also clearly indicate that the benefits of clicker use in a management setting are similar to those experienced in other disciplines in terms

Table 7. Student Comments on Clicker Weaknesses

	Number of Responses	
	Clicker Section	Non–Clicker Section
Problems getting it to work correctly/ technical difficulties	24	4
Fear of losing clicker	7	0
Remembering to bring it to class	2	1
Limited use beyond quizzes and polling	1	1
Slows down class when people do not pay attention	1	0
It takes attendance	1	0
The screen can be difficult to read	1	0
Scratches/get damaged easily	1	0
Costs involved	0	3
Potential for cheating	0	1
Some people do not like using technology	0	1
Time wasted passing out and collecting clickers[a]	0	1
Total comments	38	12

a. No passing out and collecting of clickers was involved with the clicker section.

of actual performance, satisfaction, perceived performance, participation, and feedback. The number of student comments highlighting the strengths of the clicker technology reiterates the findings of this study and past studies with regard to class participation, reinforcement of concepts, attention, and feedback. Furthermore, it seems these comments provide the backdrop for the difference found in the academic performance on exams between the two class sections. Students who participate in class, pay attention, discuss concepts, receive feedback on their performance, and receive reinforcement of concepts should score higher on exams than their counterparts who do not.

The comments regarding weaknesses of the clicker technology were primarily centered on the technical problem experienced during the semester that was outlined earlier. One comment, "Has potential for cheating," stood out as a possible significant problem. Depending on the size of a class, it could be easy for students to cheat using a clicker. For example, one student could input answers on multiple handheld clicker units, or a person not enrolled in the class could pose as an enrolled student and enter answers on

the enrolled student's behalf. Although these types of cheating are not exclusive to the use of clickers, the use of clickers may make such methods of cheating easier.

Limitations and Future Research

This study is not without limitations. First, the study only involved one instructor. Although the use of one instructor eliminates the potential for a difference of instructor effect that could have occurred if multiple instructors were involved, it opens the door to instructor bias. Although efforts were taken to ensure the clicker and non–clicker sections were exposed to the course information in the same way, it is possible that minor differences occurred. Without some type of comparison mechanism in place, such as video-taping each lecture or having an individual monitor both lectures, any differences would be difficult to identify.

A second limitation lies in the potential for the Hawthorne Effect (French, 1950). As part of the university institutional review board requirements, the clicker section was informed that the use of clickers in the class was part of a pilot study to determine whether or not clickers would be a useful tool in the classroom and was being considered for use across the department. Thus, the students in the clicker section may have altered their behavior such that academic performance on exams increased due to student awareness of the study.

A final limitation to the study involves the limited scope of the sample. The sample included only upper-level (junior and senior) management students. Future studies may want to examine whether the findings of this study can be replicated with lower-level (freshmen and sophomore) management students in introductory courses. Additionally, the sample consisted of traditional students who are familiar with learning and using new forms of technology. Since the number of older, nontraditional students is increasing, future research may want to examine whether the same results are found with nontraditional students.

Many other questions still need to be answered regarding clicker use in the classroom. Would students find clickers as/more useful in classes requiring high levels of quantitative work? What types of classes are most suitable for clicker use (formal lecture, quantitative problem solving, discussion) and what types of students receive the most benefit from clicker use (lower-level, upper-level, traditional, nontraditional)? These are all questions that will need to be addressed as the exploration of clicker technology continues. Researchers within the management discipline are well positioned to help answer these questions because of the breadth of management courses and the different types of teaching formats required for those courses.

Appendix

Clicker Studies and Criteria Investigated

Author (Year)	Discipline	Sample Size	Perform Actual	Satisfaction	Perform Perceived	Attention Span	Attend	Participation	Feedback	Ease of Use
Beekes (2006)	Acct.	Unk		X		X	X (n.s./ SR)	X (O)		X
Carnaghan and Webb (2007)	Acct.	186	X (n.s.)	X	X			X (–)		
Cunningham (2008)	Acct.	88		X (n.s.)	X (n.s.)	X (n.s.)				
		326		X	X (n.s.)	X				
Hatch, Murray, and Moore (2005)	Anatomy	144		X (Q)	X					
	Environ. science	Unk		X						
Prather and Brissenden (2009)	Astron.	218			X	X	X (SR)			
Trees and Jackson (2007)	Physics, comm., astron.	1,543			X		X (SR/ PG)			
Addison, Wright, and Milner (2009)	Biochem.	152	X (n.s.)	X	X	X	X (n.s./ SR)	X		
Barnett (2006)	Biology	Unk							X (Q)	
	Biology	Unk							X (Q)	
	Physics	Unk							X (Q)	
Caldwell (2007)	Biology	Unk	X	X			X			

(continued)

Appendix (continued)

Author (Year)	Discipline	Sample Size	Perform Actual	Satisfaction	Perform Perceived	Attention Span	Attend	Participation	Feedback	Ease of Use
Crossgrove and Curran	Biology	185	X (n.s.)		X	X		X	X	
(2008)	Genetics	44	X (n.s.)		X	X		X	X	
El-Rady (2006)	Biology	125	X				X			
Freeman et al. (2007)	Biology	173	X				X			
Herreid (2006)	Biology	450	X (O)	X (Q)			X			
Knight and Wood (2005)	Biology	Unk	X	X			X			
Preszler, Dawe, Shuster, and Shuster (2007)	Biology	550	X	X	X	X	X (SR)			
Ribbens (2007)	Biology	Unk	X				X			
Blackman, Dooley, Kuchinski and Chapman (2002)	Chemistry	Unk	X (n.s.)	X	X					
Hoekstra (2008)	Chemistry	>2,000		X						
Fitch (2004)	Comm. disorders	55		X	X	X				
Rice and Bunz (2006)	Comm.	46		X (Q)						X
MacGeorge et al. (2008)	Comm., forestry, leader	390		X	X		X (SR)			X

(continued)

Appendix (continued)

Author (Year)	Discipline	Sample Size	Perform Actual	Satisfaction	Perform Perceived	Attention Span	Attend	Participation	Feedback	Ease of Use
Johnson (2005)	Dentistry	78			X					
Greer and Heaney (2004)	Earth science	582		X	X		X (PG)			
Elliott (2003)	Econ.	47		X		X	X (SR)			X
Ghosh and Renna (2009)	Econ.	1,597		X	X		X (n.s.)			
Salemi (2009)	Econ.	406		X	X		X (PG)	X		
Nicol and Boyle (2003)	Engineering mechanics	114			X				X	
Latessa and Mouw (2005)	Family medicine	46		X	X	X				
McConnell, Steer, and Owens (2003)	Geology	Unk	X	X (Q)						
Burton (2004)	Law	160		X	X					
Chan and Knight (2010)	Library instruct.	291	X (–)	X				X		
Hoffman and Goodwin (2006)	Library instruct.	Unk		X (Q)		X (Q)		X (Q)		
Matesic and Adams (2008)	Library instruct.	400						X		
Petersohn (2008)	Library instruct.	48	X							

(continued)

Appendix (continued)

Author (Year)	Discipline	Sample Size	Perform Actual	Satisfaction	Perform Perceived	Attention Span	Attend	Participation	Feedback	Ease of Use
Eastman, Iyer, and Eastman (2011)	Marketing	97		X	X	X				
Lincoln (2008)	Marketing	68				X	X (PG)		X	X
Sprague and Dahl (2010)	Marketing	93		X	X			X		
Ueltschy (2001)	Marketing	72	X (n.s.)	X	X			X		
	Marketing	38	X	X	X			X		
	Cultural diversity	31	X (n.s.)	X	X			X		
Copeland, Hewson, Stoller, and Longworth (1998)	Medical	167		X	X	X			X	
Menon et al. (2004)	Medical	12		X						
Miller, Ashar, and Getz (2003)	Medical	164		X		X		X		X
Patterson, Kilpatrick, and Woebkenberg (2010)	Medical surgical	38	X (n.s.)	X (Q)		X (Q)		X (Q)	X (Q)	
Schackow, Chavez, Loya, and Friedman (2004)	Medical	24	X							
Trapskin, Smith, Armitstead, and Davis (2005)	Medical	83	X	X	X			X		

(continued)

Appendix (continued)

Author (Year)	Discipline	Sample Size	Perform Actual	Satisfaction	Perform Perceived	Attention Span	Attend	Participation	Feedback	Ease of Use
Uhari, Renko, and Soini (2003)	Medical	39			X					
Nelson and Hauck (2008)	MIS	175	X (n.s.)	X	X		X (PG)		X	
DeBourgh (2008)	Nursing	65		X	X				X	X
Stein, Challman, and Brueckner (2006)	Nursing	283	X (n.s.)		X	X (Q)			X	
Yourstone, Kraye, and Albaum (2008)	Operation mgmt.	93	X							
Slain, Abate, Hodges, Stamatakis, and Wolak (2004)	Pharm.	137	X	X	X		X (n.s./ SR)			
Stuart, Brown, and Draper (2004)	Philos.	~140		X (Q)		X (Q)		X (Q)	X (Q)	
Bullock et al. (2002)	Physics	~200	X				X (PG)	X		
Koenig (2010)	Physics	142		X	X	X (Q)	X		X	
Majerich, Stull, Varnum, and Ducette (2011)	Physics	152	X							
Poulis, Massen, Robens, and Gilbert (1998)	Physics	288	X		X					
Reay, Bao, Li, Warnakulasooriya, and Baugh (2005)	Physics	127		X				X		

(continued)

Appendix (continued)

Author (Year)	Discipline	Sample Size	Perform Actual	Satisfaction	Perform Perceived	Attention Span	Attend	Participation	Feedback	Ease of Use
Kam and Sommer (2006)	Political science	Unk		X		X				
Beckert, Fauth, and Olsen (2009)	Psych.	170		X	X	X	X (SR/ PG)			
Copas (2003)	Psych.	16		X (Q)						X
Mayer et al. (2009)	Psych.	111	X							
Morling, McAuliffe, Cohen, and DiLorenzo (2008)	Psych.	~645	X			X (n.s.)				
Paschal (2002)	Physio.	63	X (n.s.)							
Gauci, Dantas, Williams, and Kemm (2009)	Physio.	175	X	X	X	X	X (n.s.)	X		
McFarlin (2008)	Physio.	312	X							
Mollborn and Hoekstra (2010)	Sociology	294		X (Q)			X (SR)			
Kaleta and Joosten (2007)	Unknown	2684	X	X	X	X		X	X	

Note: X = significant outcome; X (n.s.) = outcome not significant; X (–) = significant negative relationship; SR = student reported; PG = clicker participation/attendance part of grade; O = observed, not measured; Q = qualitative data.

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