An Empirical Investigation of Clicker Technology in Financial Accounting Principles

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ABSTRACT

The effects of clicker-use and active learning classroom activities on student performance in financial accounting principles were examined. A repeated measure design was used to compare performance on four exams between a clicker group and a non-clicker group, after controlling for GPA and age. A matched-pairs t-test was used to compare the effects of clickers and structured, peer-instruction (PI). In addition, students' perceptions of clicker-use were evaluated against the literature.

The results indicate that the integration of clickers with structured PI, significantly affects students' performance. However, the use of clickers, in and of themselves, did not produce significantly higher performance results for students. Despite the limited performance effects, most of the students believe they learn more and perform better because of the clicker technology. They believe they are more actively engaged, are more motivated, and are more likely to attend class because of the clickers.

INTRODUCTION

Clicker technology is similar to the famous television show, "*Who Wants to be a Millionaire?,"* where the audience responds with a remote control-type device to multiple-choice questions that appear on a screen at the front of the room. Although individual responses are anonymous and known only to the professor and the student, the "group" responses are tallied and displayed in a histogram on the screen, after the audience (students) completes the "voting." The histogram provides immediate feedback to the instructor, the class as a whole and to individual students. Students can quickly relate their response to the rest of the class and to their individual performance. The histogram also provides a mechanism for the instructor to follow-up with more detailed discussion and for students in the class to discuss their responses with each other (peer instruction). As in "*Who Wants to be a Millionaire?,"* the response time is limited and is indicated by a countdown timer, visible to all in the classroom.

Clickers allow for anonymous student responses, in class, without the embarrassment of being "put on the spot." In the pure, traditional classroom, the teacher lectures and students sit while passively absorbing the professor's lecture. In a little less-than-pure, traditional classroom, the professor asks questions and one student, at a time, is allowed to respond. Some students may know an answer, or think they know an answer, but not respond. Clickers allow all students to participate, simultaneously. Most traditional classes have the eager beaver, the student that knows all the answers and responds very quickly (eager-beaver effect). Other students typically wait for the eager beaver to respond, without engaging their brain at all. Clickers mitigate, if not remove, the eager beaver effect.

The primary purpose for using the clicker technology in this study was to maintain the "feel" of a small classroom (faculty-student interaction) while teaching in a larger classroom. The clicker system allows the professor and the students to communicate with each other via the histogram display. The professor is able to replace visual inspection of students' faces for understanding with class responses to the clicker questions. This feedback allows the professor to immediately assess students' conceptual understanding and problem-solving capabilities and adjust the lecture accordingly.

Many in the literature suggest that clickers are an active learning technique. Some have stated that clickers provide the mechanism for each student to engage their thought processes; allowing all students to move from the passive listener and to participate in the learning process. Thus, many clicker researchers imply, if not directly state, that the use of clickers increases performance. However, it is questionable that simply depressing a button on a remote control-type device translates into active learning.

True enough, students move beyond passive listening by pushing a button on their remote device. Whether the "button pushing" on the remote device translates into "being engaged" is not visible or theoretically justified. In addition, the conflicting empirical clicker research evidence on actual performance (evaluated below) brings into question whether the clicker technology, in and of itself, is active learning. The current research seeks to determine whether or not the clicker technology is, in its' own right, an active learning technique.

Despite whether or not the use of clickers is deemed to be an active learning technique, the use of clickers provides a mechanism for "all" students to participate. As revealed in the literature section, students perceive that clickers increase their attention, motivation, course performance, and retention of material. In general, students' perceptions across studies appear to be fairly consistent—students like using clickers.

One purpose of this study is to ascertain whether students in financial accounting principles produce the same satisfaction levels with the clicker technology as reported in the literature. A second purpose of this study seeks to resolve the issue regarding the effect of clicker use on "actual" (versus perceived) student performance. As revealed in the literature review section, studies regarding the use of clickers in the classroom produce conflicting results; either increased performance or no effect. Carnaghan and Webb (2007) produced limited evidence that the implementation of active learning techniques simultaneously to the integration of clickers creates the increases in students' performance. A review of the literature bears out this suggestion and provides the foundation for this study.

A final purpose of this study is to evaluate the effect on performance of the combined use of peer instruction (PI) and clickers. This study was designed to isolate the effects of clickers alone and clickers with PI. A non-clicker group was compared to a clicker group with an element of both groups' final grades consisting of class participation. Clicker technology was integrated during the entire semester in the clicker group with PI integrated after midterm.

The next section provides a literature review of clicker research and the ensuing hypotheses. The subsequent section contains the methodology and is followed by the results and discussion section. Finally, the limitations of the study, conclusions, and future research appear in the final section.

LITERATURE AND HYPOTHESES DEVELOPMENT

Clicker technology researchers provide various theoretical rationales to support the use of clickers and their effects on students' performance. Many provide the Dufresne et al. (1996) social constructivism theory as the rationale behind increased student performance with the clicker technology (Nichol and Boyle 2003). Dufresne' et al. (1996) social constructivism relies heavily on PI. PI begins with posing a question to the students in class; where initially, students respond without conferring with classmates. The histogram of responses is revealed to the class; after which students are encouraged to discuss, in small groups, the question and responses. After the groups' discussions, students are allowed to respond to the question a second time.

Edmonds and Edmonds (2008) provide the "theoretical arguments made by accounting educators" ... "that active learning promotes student performance" (p 422). Edmonds and Edmonds (2008) also rely on a subset of Bonwell and Eison's (1991) characteristics that describe "active learning." More specifically, Edmonds and Edmonds (2008, p 423) put forth that the use of clicker technology involves five of Bonwell and Eison's (1991) seven characteristics:

1. students are involved in more than passive listening;
2. students are engaged in activities;
3. there is less emphasis placed on information transmission and greater emphasis placed on developing skills;
4. students can receive immediate feedback from their instructor; and
5. student motivation is increased.

Students' Perceptions

Evidence of student satisfaction with the use of clickers in the classroom abounds in the literature. Overall, students view the use of clickers in the classroom positively in terms of encouraging and/or enhancing active engagement, motivation, attention-span, interest level, and preparedness.

Motivation/Participation/Attention

Abrahamson's (1999) Harvard and University of Massachusetts students produce very high scores (both at 90%) for the use of clickers as a motivator. More than 75 percent of Williams and Boyle's (2008) sample report that clickers serve as a motivator. Kay and Knaack (2009) report a satisfaction level of 63% of the students.

More than 80 percent of the Harvard and University of Massachusetts students believe they are more engaged in the classroom as a result of using clickers (Abrahamson 1999). Slain et al. (2004) reported similar results for three separate courses, as does Barnes (2008) and Kaleta and Joosten (2007).

Students' perception results vary between higher scores of 80-96 percent agreeing that the class is more enjoyable (Preszler et al. 2007, Slain et al. 2004) and only 60-70 percent agreeing (Abrahamson 1999). Along this same line, Caldwell (2007) found that 88 percent prefer the use of clickers over non-use.

The majority of students agree that they pay more attention in class because of the use of clickers (Abrahamson 1999, Kaleta & Joosten 2007). Latessa and Mouw (2005) report significantly higher percentages of their students (99%) believe they pay more attention because of the use of clickers. Boyle et al. (2002), Dufresnes et al. (1996), Miller et al. (2003) and Crossgrove and Curran (2008) report scores above 4.0 on a 5-point Likert scale for this same variable.

Help to understand or retain material

Reay et al. (2008) student surveys produced positive results in that students enjoy using the clickers and believe that clickers help them learn. Several studies report that at least 80 percent of the students agree or strongly agree that the clickers help them to understand and/or learn the material (Abrahamson 1999, Cue 1998, Latessa & Mouw 2005, Pradham et al. 2005).

H1-1: Financial accounting principles students have overall positive perceptions of clicker-use in the classroom with respect to being actively engaged, paying attention, retaining the course material, motivation levels, performance, attendance, and interest in the course.

Performance

A constant in the clicker and performance literature is the absence of findings that students experience negative effects on performance from the use of clickers. On the contrary, students believe the use of clickers positively affects their performance (Edmonds and Edmonds 2008, Crossgrove and Curran 2008). Despite these positive student perceptions, the empirical evidence of clicker use on student performance is mixed. Researchers report of no effects for the class as a whole (Crossgrove and Curran 2008, Nelson and Hauck 2008, Miller et al. 2003), increased

performance for the class as a whole (Pradham et al. 2005, Shackow et al. 2004, van Dijk et al. 2001, Poulis et al. 1998), increased effects on a subgroup of students (Caldwell 2007, Edmonds and Edmonds 2008), or increased performance based on select groups of assessments (Crossgrove and Curran 2008, Slain et al. 2004) result from the use of clickers.

The mixed results in the clicker performance literature require a critical analysis of this literature. It is not established that the use of clickers truly qualifies as an active learning technique, or at least a technique that leads to positive effects on performance.

Positive performance effect

The literature on positive performance effects exist across disciplines and various pedagogies. However, each study contains confounding events that might contribute to increased performance. The major confounding events can be classified into two major types: (1) comparisons of traditional lecture classes to classes with active learning activities (beyond the clicker itself) and (2) limited designs and or measurements.

Poulis et al. (1998) were among the first to present performance findings in the clicker research. They report a significantly higher pass rate for the clicker group than the non-clicker group where the non-clicker group received traditional lectures with very little in-class interaction. Although Poulis et al. (1998) state, "... results demonstrate ... APF [clickers] ... increasing the mean pass rate ..." (p. 441), they acknowledge the possibility of the potential increased pass rate effect due to increased student and faculty interactions, as well as additional professor explanations after clicker questions and responses. Others that report of increased performance describe the additional professor explanations provided during the clicker sessions (Blood and Neel 2008, Donovan 2008, Pradham et al. 2005, Schakow et al 2004, Sharma et al. 2005). Barnes (2008) El-Rady (2006) added group discussions and/or PI during the clicker sessions. Slain et al. (2004) requested that student volunteers explain clicker question responses to the class; using this as a method to generate class discussion.

Schackow et al. (2004) provide evidence to the "additional activities" associated with clickers by comparing performance of one set of students exposed to three instructional methods. They compared a pure lecture with no interaction method, an interactive with structured multiple-choice questions but without clickers method, and a clicker method. The second two methods allowed for extensive professor-student interaction. The students performed significantly better when taught with the clickers than they did when the instruction was purely lecture. However, the clicker method did not produce significantly better results when compared to the interactive instructional method.

Preszler et al. (2007) also provide support that the additional activities produce significant results for the more active groups. Preszler et al. (2007) found significantly higher examination scores when clickers were used more often (Preszler 2007). They credit to the use of clickers as opposed to the increased student-faculty interaction created from the additional use of the technology (Preszler et al. 2007).

Several studies with positive performance effects reveal limitations in their design or measurements. Students in the clicker group were held accountable for "homework" in Edmonds and Edmonds (2008). Reay et al. (2008) also introduced a particular question sequence in the terms when the clickers were introduced into their traditional lectures. Although the non-clicker group had "access" to the sequenced questions, there is no mention of whether the students actually were exposed to these during class. Instead, Reay et al. (2008) clearly state that the class was "taught in a traditional manner" (p. 174).

Schackow et al. (2004) averaged weekly quiz grades for each of their three different instructional methods (pure lecture, interactive, and clickers) as the measures of performance. The interactive and clicker lectures contained multiple-choice questions presented in the form of presentation software slides, with the clicker group using the clicker system and the interactive group verbally discussing the responses. Although the same presentation software slides were utilized in the pure lectures, the pure lectures did not contain the multiple-choice questions. These same

multiple-choice questions presented during the session were used as the measurement of performance in all instructional methods. Slain et al. (2004) report significant results for three different courses but the same measurements are not significant across courses.

No Effect

Six of the seven studies that revealed limited or no effects from the use of clickers contained specialized samples and/or limited exposure to the clickers. Carnaghan and Webb (2007) found limited effects of the clickers with accounting honors' students. van Dijk et al. (2001) compared a one-hour lecture of a pure-lecture (control) group to an clickers-group and an clickers-PI group; differences between the groups did not emerge. Their sample contained students majoring in the field of engineering; albeit, the course studied was a basic beta sciences' course required of all engineering students. Paschal's (2002) group was also engineering majors. Crossgrove and Curran (2008) had a sample of biology majors; Bunce et al. (2006) studied nursing students; and Miller et al. (2003) group contained practicing, health care professional from a one-hour continuing education course.

Nelson and Hauck's (2008) study of business students in a basic MIS course did not find significant differences between performance of clicker-students and non-clicker students; they do not mention their performance measurement instrument but note that each comparison group had different faculty members and exam content. Although van Dijk et al. (2001) administered a mechanic's knowledge pre-test to ascertain the similarities between their control and treatment groups, variables to control for individual performance of the subjects were not utilized. The lack of control variables is a common theme among the studies that did not find significant effects (Crossgrove and Curran 2008, Nelson and Hauck (2008).

Control Variables

Edmonds and Edmonds (2008, p 429) report an average of 3.12 percentage points higher for the clickers-students over the non-clickers students, after controlling for age, gender, cumulative GPA, and ACT score. Carnaghan and Webb (2007) found "limited GRS [clicker] learning effect" in a management accounting course and suggest the effect of increased performance reported in other studies do not remove the coupling effect of clickers and change from traditional lecture to an active learning environment. Carnaghan and Webb (2007) provide evidence of the decoupling effects.

H1-2: Accounting principles students that use clickers outperform accounting principles students' that do not use clickers, after controlling for students basic aptitude (SAT), motivation (CGPA), gender, and age.

H1-3: Accounting principles students that use clickers with peer instruction (PI) perform better than using clickers alone.

METHODOLOGY

Sample and Pedagogy

The sample consists of students enrolled in financial accounting principles courses at an AACSB-accredited, mid-sized, southeastern United States university. Both groups met for 15 weeks; the control group met during the spring of 2009 and the experimental group met during the spring of 2010. All sections were taught by the same instructor, who had over 20 years experience teaching financial accounting principles. All sections met in the mornings. The same textbook (*Financial Accounting, 6*th ed, Weygandt, Kimmel, and Kieso), syllabus, and point allocation for participation (5%) and examinations (95%) were used for both groups.

Both groups received the same lectures, homework assignments, and exams. Class notes were created during class, saved to a file after class and made available, via the web, to the students after each class period. Homework assignments were identical and appeared on the syllabus; specific homework assignments were made daily. Although homework was not collected from either group, it served as the basis for participation points. For both groups, homework solutions were presented and discussed in class. All class questions were addressed; however, a notably

greater amount of questions were asked in the control group than in the experimental group. Participation points were accumulated during class for both groups.

The use of the clicker technology for participation and explanations of the clicker technology on the syllabus for the experimental group were the major differences between the control and experimental groups. The control group's participation points were primarily assigned to individual students that volunteered solutions or discussion during class. The professor made marks on a seating chart during class as individual students contributed to the class. Students were informed at the beginning of the semester that their final participation grade was based on their number of responses relative to the number of responses to others in the class. They were reminded periodically during the semester of this policy.

The clicker group received participation points, initially, by simply responding to clicker questions in class; both correct and incorrect responses received full credit. Subsequent to the first exam and up to the second exam, students earned points by correctly responding to clicker questions on their own. During the second half of the class (coverage of the third and fourth exams), peer-instruction was integrated into the class. On average, each class session contained four clicker questions. The sequence of responding to a single clicker question was to first reply to the question as an individual; after the histogram of individual responses was revealed, students discussed the question in student groups of three. After the student discussions, the question was revealed again, for a second opportunity to respond correctly. Students earned one-half a point for each correct response.

The same exams were administered to both the control and clicker groups at about the same point in the semester. Exams were primarily a multiple-choice format with the multiple choice questions' responses re-ordered to create multiple versions for individual examinations, for each group. Carlson and Ostrosky (1992) reveal that ordering of multiple-choice questions impacts student performance; however, performance is not affected when the responses are re-ordered.

Data Collection and Methods

Student perception responses were collected from the clicker group with the clicker technology. Nine questions were posed to the class on the first day after midterm, prior to the integration of peer instruction. Two final perception questions were administered on the last day of class (see Table 1).

Students were asked to respond to the midterm perception statements on a 5-point, Likert-type scale from strongly agree to strongly disagree; although, some of the responses were reverse-ordered to enhance the validity of the responses. As a second method to enhance the validity of the responses, some of the statements appeared in the negative form. The two statements posed on the last day of class contained only positive and negative responses; the middle (neutral) response was eliminated.

Performance was measured by scores earned on each of the four semester exams. Cumulative grade point average (CGPA) and age as of the beginning of the semester were retrieved from the students' official records. SAT scores were retrieved where available. Some students with SAT scores only had the Verbal and Math portions, without the writing portion. As such, total SAT scores consist of the math and verbal portions only. Students with ACT scores instead of SAT scores were retrieved and converted to the math and verbal-SAT equivalent. Raw scores (not curved) earned on each exam were recorded for analysis purposes.

Given the over-abundant reports in the literature of students' perceptions to the use and benefits of clickers in the classroom, simple visual comparisons of clicker use by the clicker group will be made to the literature. The percentages of students' responses from this study will appear in the results section. Univariate ANACOVAs were used to test for (1) differences in each version for each exam within each group, (2) differences in each version of each exam between the groups, and (3) differences in each exam between the two groups. A repeated measures design, with raw scores earned on each of the first four exams as the multiple-dependent variable and control independent variables, is used to test the effect

Table 1
Results of Perception Questions (Percentages)

#	Question	n	SD&D[1]	N	A&SA
5	I am more actively engaged in the class because of the use of clickers.	70	3	17	80
1	I pay more attention in class because of the clicker questions	70	13	19	69
4	I like seeing how the rest of the class responded to clicker questions.	69	6	26	68
9	The use of clickers makes the class more interesting.	70	13	34	53
2	I believe I remember more of the class material as a result of using the clickers in class.	70	11	37	51
7	I come to class more prepared because of the use of the clickers.	70	31	43	26
	Questions in the negative form:				
3	I am less motivated because of the clicker questions.	70	76	20	4
8	The use of the clickers has no impact on my class performance.	69	59	26	14
6	The use of clickers does not impact my decision to attend class.	70	50	23	27
The following two questions were asked on the last day of class					
	I believe the use of clickers in class has helped to increase my knowledge of accounting.	52	18	n/a[2]	83
	I believe discussing the questions with my classmates was beneficial in learning accounting (peer instruction).	52	26	n/a	75

1SD&D=Strongly Disagree and Disagree; N=Neither; A&SA=Agree and Strongly Agree

2N/A = response not an available as an option.

of clickers as a method to increase performance. The model appears as:

$$\text{Exam Score} = \alpha_{0} + \beta_{1}\text{Group}_{i} + \beta_{2}\text{CGPA}_{i} + \beta_{3}\text{SAT}_{i} + \beta_{4}\text{Age}_{i} + \beta_{5}\text{Gender}_{i} + \varepsilon_{i}$$

where:

Exam Score: four (4) scores for each student, representing scores earned on each of four (4) semester exams;
Group: 1 = non-clicker, 2 = clicker;
CGPA: Cumulative GPA at beginning of term;
SAT: Math + Verbal portion or ACT-equivalent of SAT-Math and Verbal
Gender: 1=Female, 2=Male
Age: At the beginning of the term.

NOTE: SAT was dropped from the model because of a significant correlation to Age; Age was maintained to preserve the sample size as SAT/ACT scores were not available for all of the students. Also, Gender was dropped from the model as it revealed a lack of significance in the ANACOVA tests.

Paired t-tests, for each group, were used to test the effects of peer-instruction. The average scores earned on the first two exams are compared to the average scores earned on the second two exams (after peer-instruction integrated into the clicker group), for each group separately. If differences in the pre- and post-test measures are a function of the difficulty level of the material, then differences or lack thereof should appear for both the clicker and non-clicker groups. A significant difference should result in the clicker group, but not the control group, if peer-instruction impacts student performance. If peer-instruction positively impacts performance, the post-test averages should be greater than the pre-test averages.

RESULTS AND DISCUSSION

Students included in the study include those that at least completed the first exam. The combined sections totaled 159, 132, 111, and 105 students for Exam #1, #2, #3, and #4, respectively. Scores from these students were used to test for differences between versions within an exam and to test for differences between clicker use on each of the four exams (see Table 2). Thirty-one in the control group and 60 students in the clicker group completed all four exams on exam day. Scores of these 91 students were used to test the effects of clickers alone (H2) and clickers combined with peer instruction (H3).

The basic demographics between the clicker and non-clicker groups are comparable with average ages of 21 and 22 for the control and clicker groups, respectively. The average cumulative GPA was 2.62 for both groups. The control group had slightly more females (62%) than the clicker group (58%). The distribution of freshmen, sophomores, juniors and seniors was relatively the same.

Perceptions (H1)

Overall, the perception responses of the clicker group parallel the results reported in the literature (see Table 1). Although the overall results indicate that positive effects accrue during class, this does not necessarily extend to outside of class activities (preparation). Students believe that the use of clickers helps to maintain their attention, as well as engage and motivate them. By the end of the semester, a larger percentage of students believed that clickers helped to increase their knowledge of accounting over their beliefs about performance at midterm. This change in perception could be the result of integrating peer-instruction with the clickers after midterm. Corroborating support exists with the positive perceptions to the peer-instruction question posed on the last day of class, with 83 percent of the students agreeing that clickers helped them learn accounting.

Performance (H2 and H3)

A preliminary view of the groups' average exam results reveals that the non-clicker group outperformed the clicker group on each exam except the fourth exam (see Table 2). However, these results do not account for individual performance or the control. The clicker groups' exam average after the integration of peer instruction (Exam #3) increased; they maintained this increase for the remaining exam. This same pattern does not exist for the non-clicker group. The univariate ANACOVAs for each exam between the clicker and non-clicker group indicate that they are not significantly different. Cumulative GPA was a significant variable for each exam and age is significant for three of the four exams.

The repeated measure results for the two groups as a whole, indicate a lack of significant difference between the clicker and control groups (p=0.45) (see Table 3). Consistent with the univariate results and the literature, CGPA and Age are both significant variables. The results suggest that the use of clickers, in and of themselves, does not produce the intended outcomes of active learning techniques in the classroom. Thus, the second hypothesis is not supported.

Table 2
Descriptive Statistics –Exam Results

	Exam #1			Exam #2			Exam #3			Exam #4		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Non-clicker	51	67.51	14.94	47	61.21	17.83	35	75.17	22.52	35	65.60	20.35
Clicker	108	65.31	17.01	85	59.74	14.87	76	68.00	19.91	70	68.49	14.61
Total[1]	159	66.02	16.35	132	60.27	15.94	111	70.26	20.94	105	67.52	16.70
ANACOVA p-values		0.35			0.40			0.09			0.60	

[1] The results for the reduced sample of students that took all four exams on exam day (n=91) reveal similar results.

TABLE 3
Repeated Measures: Exams = a + Group + CGPA + Age + e
n: Control group = 31; Clicker group= 60

Source	Type III Sum of Squares	df	Mean Square	F	p-value
Group	387	1	387	0.910	0.450
CGPA	18,510	1	18510	43.47	0.000
Age	2,724	1	2724	6.40	0.020
Error	38,327	88			

The paired t-tests, for the two groups separately (see Table 4), were used to test the effect of peer-instruction. Significant results emerge for the clicker group (p=0.046) but not for the control group (p=0.170). Although the non-clicker group scored approximately two percentage points higher on the second set of exams relative to the first set of exams, the difference was not significant. There was not a change in the course for the control group between the first two exams and the second two exams; as such, a difference was not expected.

However, peer instruction was integrated into the clicker group after the second exam. It was expected that if peer instruction assisted in students' learning, then a significant difference would emerge. As expected, the clicker group scored significantly higher (71.14) after the integration of peer instruction than they did before the use of peer instruction (68.34). These results support the third hypothesis.

LIMITATIONS, FUTURE RESEARCH, AND CONCLUSIONS

As with any study, this study does have limitations. One limitation, although minimizing the effect of different teachers, is that both groups of students were taught by the same professor. This professor had taught both large and small sections of financial accounting principles. A second limitation is that the two groups were from the same institution. Although minimizing the effects of university-specific variables of different institutions, the one-university limitation prevents generalizability to other institutions.

Future clicker researchers in accounting education should focus on the type of questions, frequency of clicker questions, percentage of points allocated to clicker responses, and measurements of performance. Donovan's (2008) results leads one to believe that the value of the clicker technology rests with the idea of posing a question (to stimulate thinking) as opposed to the use of the technology itself. Credibility to this supposition could be confirmed by expanding the number of questions per class-session from six questions to a substantially larger number of questions.

In conclusion, the perceived benefits expressed by students regarding the use of clickers in financial accounting principles are overwhelming. Students believe that the use of clickers increases their performance, attendance, and motivation. Capitalizing on these positive attitudes to increase learning should be at the forefront of clicker use in the classroom. These positive beliefs might also be the motivation for implementing the use of clickers in the classroom.

TABLE 4
Paired t-tests: Pre- and Post-tests

		Pre-tests		Post-tests		t-tests	
	n	Average	Std. Dev.	Average	Std. Dev.	t-value	p-value
No-clicker	31	69.75	12.44	72.34	16.49	1.41	0.170
Clicker	60	68.34	13.09	71.14	14.36	2.04	0.046

The benefit of the clickers in the classroom rests more with the "other" activities triggered with their use. One of the other activities is the professor's ability to provide immediate feedback based on the histogram results. Responses to a clicker question that produce a high percentage of incorrect responses, triggers the professor to provide further explanation. In addition, the use of the clicker system, together with peer instruction, facilitates focused discussions between the students.

Integrating formal questions via PowerPoint slides possibly creates students' cognitive engagement more than the professor simply posing questions out loud in class. The formalized appearance on a slide might trigger the student to re-focus on the lecture, where the verbally spoken question might not.

Do not expect that the superficial use of clickers will increase performance. The use of clickers to simply administer in-class quizzes or exams is not likely to increase performance. The benefit of clickers in the classroom accrues with the integration of active learning activities such as peer-instruction.

Overall, the evidence in this study suggests that the use of clickers alone do not increase performance. However, the combination of clickers and peer instruction increases performance. This evidence confirms Carnaghan and Webb (2009) evidence that the additional activities associated with clickers produces higher performance.

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