THE EFFECT OF USING CLICKERS

IN HIGHER EDUCATION

SCIENCE CLASSROOMS

by

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ABSTRACT

Clickers have been used in schools for nearly a decade. However, there is limited research examining clicker influence on student achievement. Using the Mollborn and Hoekstra (2010) Clicker Model as its theoretical framework, this study investigated the influence of clicker use on higher education science classrooms. The research was conducted in two parts: 1) a causal comparative study based on three science courses taught over two semesters examining whether there was a statistical difference in student achievement in the classes that used clickers and the classes that did not; and 2) a descriptive survey that explored the perceptions of teachers' about clicker use. Data collection had two phases: collection of student final grade averages in each class and collection of survey responses. For Research Question 1, the investigator used t-tests and a Mann Whitney U test to determine statistical differences in grades in clicker vs. non-clicker classes. For Research Question 2, the responses were coded to generate a factor analysis, descriptive statistics, and percentages. For Research Questions 3-5, the investigator coded the responses to four open-ended questions and identified themes. This research found statistically significant differences in student grades in the three science courses under study. The survey data identified positive perceptions of teachers' using clickers. Lastly, the study revealed teachers' perceived clickers as beneficial and recommended mentoring programs for educators considering clicker integration. The major conclusions of the study were that students in clicker classes outperformed students in classes without clickers and that teachers (n=64) found clickers beneficial to teaching and learning.

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CHAPTER I:

INTRODUCTION TO THE STUDY

Introduction

Traditional science classes will continue the trend of low enrollments and high dropout rates unless teaching strategies change drastically (Herried, 2010). This study hypothesizes that using clickers, hand held response devices, have multiple positive effects for both the student and the teacher, particularly in the discipline of science. Using instructional strategies that incorporate active learning with tools like clickers can increase student grades, improve student satisfaction, and increases content retention (Herried, 2010). Using clickers as a teaching strategy can transform the way students learn (Herried, 2010). According to Goode, Willis, Wolf, and Harris (2007), teachers must understand that students need control over how and when they learn. Clickers give students control over their own learning. Clickers allow course content or concepts to be learned from a student-centered perspective. Tormey and Henchy (2008) suggested that "students learn more when they are actively engaged with the material" (p. 304).

Unfortunately, in most traditional classrooms, active engagement of students does not occur. Students sit passively taking notes while the teacher lectures. No active learning occurs when this method is used in science classes (Herried, 2010). Shiratuddin, Hassan, and Landoni (2003) argued that, in order to keep up technologically with our twenty-first century students, instructors must challenge their students by giving them more control over what, when, and how they learn content.

The theoretical framework for this study on clickers was derived from Mollborn and Hoekstra's (2010) Clicker Model and Somekh and Saunder's (2010) Theory of Transformative Learning. The Mollborn and Hoekstra (2010) Model was used to research the adoption of clickers by faculty. The theory was used to help students learn by producing digital content.

Clickers challenge educators to reconsider "what is taught, how it is taught, and how learning is assessed" (Bransford, Brown, & Cocking, 2000, p. 13). Consequently, Nicol, Littlejohn, and Grierson (2005) indicated that instructional technologies like clickers allowed instructors to evaluate progress and provide immediate feedback to a student or groups of students. Previous research has shown that clicker use has a positive impact on student achievement, content retention, interaction, engagement and overall course impression. Student achievement examines whether clickers improve student learning as indicated by performance on course activities. Content retention examines whether clickers provoke higher level critical thinking skills (Mollborn & Hoekstra, 2010). Herried (2010) found that using clickers in his science classes resulted in higher levels of learning. Similarly, Bruff (2011) used clickers in his math classes at Vanderbilt and successfully raised the level of content learned in his lectures. Interaction examines whether clickers provoke students to ask deeper questions (Mollborn & Hoekstra, 2010). With clickers, students are drawn into the lecture by pressing a button on the clicker, allowing him or her to successfully engage in immersive activities within a classroom lecture (Bruff, 2011). Engagement, as argued by Somehk and Saunder's (2007) theory, examines whether clickers increase learning by the active participation of the student. Engagement is defined as a technique involving both the student and teacher as active participants within the lecture. Overall impression examines whether clickers increase student satisfaction with lectures (Duncan, 2005; McLauglin, 2008).

Statement of Problem

Chung, Shel, and Kaiser (2006) reported that "current instructional practices in the science fields continue to rely on traditional lectures" (p. 5). They contended that at least "83% of science instructors use the traditional face-to-face lecture as their primary method of instruction" (p. 5). Similarly, Herried (2010) and Chung et al. (2006) revealed that lecturing face-to-face is not always effective, and thus suggested other techniques, such as clickers, be incorporated into the curriculum. Chung et al. observed clickers improve learning, increase low enrollments, decrease high dropout rates, increase grades, increase content retention, and improve student satisfaction.

Purpose of the Study and Research Questions

The purpose of this study was to investigate the effect of clicker use in higher education science classes. The research questions guiding this study were as follows:

1. Is there a difference in student grades in science courses where one group was taught using traditional lectures and the other group was taught using clickers;
2. What are the teachers' perceptions of using clickers in the classroom;
    a. What are teachers' overall impressions of using clickers in the classroom;
    b. What are teacher perceptions of student engagement in a classroom using clickers;
    c. What are teachers' perceptions of a student's content retention in a classroom using clickers;
    d. What are teachers' perceptions of a student's interaction in a classroom using clickers;
3. What are teachers' perceptions of the benefits of using clickers;

4. What are teachers' perceptions of the challenges encountered when using clickers; and

5. What recommendations do teachers' have for improving clicker use in the classroom?

Methodology

This study was conducted in two parts. Part one was a causal comparative study of three undergraduate science courses taught over two semesters. The courses were *CS 202: Introduction to the Information Highway, CE 350: Introduction to Transportation Engineering* and *AY 101: Introduction to Astronomy*. During one semester, the instructors used PowerPoint with Discussion to engage the students; during the other semester, the instructors used PowerPoint with clickers to engage students. Part one of this study determined if there was a statistical difference in student achievement in classes that used clickers and the classes that did not. Part two of the study used descriptive survey research to explore perceptions of clicker use by teachers who have taught classes that used clickers.

Data Collection

Data collection had two phases: collecting raw data and collecting survey responses. The course instructors provided the investigator with individual final student grades for both semesters. For the survey, the investigator collected responses from 64 faculty via a URL using Survey Monkey. The survey consisted of 16 Likert scale questions and four open-ended questions. The Likert scale questions addressed four areas of teacher perceptions: course retention, interaction, engagement, and overall impression.

Data Analysis

A t-test was conducted to determine if there was a significant difference in student grades between the classes with clickers and without clickers (Gall, Gall, & Borg, 2007). Descriptive statistics were generated for the survey responses. The responses from the four open-ended questions in the survey were coded and themes identified (Gall et al., 2007).

Significance of the Study

This study was significant in that it provides educators with valuable evidence about the effect of clickers on student achievement and the perceptions of teachers on the use of clickers. This is important as science instructors deal with the challenges of actively engaging students in learning.

Assumptions

Three key assumptions drove this study:

1. Participants answered the survey honestly;
2. Students in the clicker section used their clicker; and
3. The instructor modified his or her lectures to incorporate clickers for active learning.

Limitations

The limitations of the study were as follows:

1. There were different levels of experience for instructors using clickers;
2. Instructors could have been nervous or anxious using the technology as an unfamiliar instructional tool;
3. No technical support in classrooms for novice instructors;
4. Survey was given in summer when some faculty had already gone;

5. Survey sample size is small; and

6. Only final course grades were compared in the student achievement portion of the study.

Organization of the Document

Chapter I introduces the study and includes the statement of the problem, significance of the study, purpose of the study and research questions, assumptions, limitations, and organization of the document. Chapter II contains a review of the literature concerning the uses, challenges, and most current research involving interactive technologies, such as clickers, in educational settings. Chapter III discusses the methodology of the study and includes the setting of the study, the purpose of the study and the research questions, details the participants, introduces the course survey instrument, and details the methodology that was used. Chapter IV presents the analysis of the data. Chapter V includes discussion, conclusions, and suggestions for future research.

CHAPTER II:

REVIEW OF THE LITERATURE

Introduction

The review of this literature begins with an overview of the issues science educators face with low enrollments, high drop-out rates, and low student achievement on hard to teach or difficult concepts, the pedagogy of clickers, followed by a discussion of using clickers with the Mollborn and Hoekstra (2010) pedagogical model and Somekh and Saunder's (2007) Theory of Transformative Learning. This chapter also presents current research on clicker technology in higher education classrooms, effects on student achievement, content retention, interaction, engagement, and overall impressions of teachers and clicker use. The chapter concludes with a theoretical framework for this study.

Herried (2010) and Chung, Shel, and Kaiser (2006) all warned that lecturing face-to-face was not effective in all classes and they suggested that other techniques, such as clickers be infused within lectures to improve learning, increase low enrollments, decrease high dropout rates, increase student achievement, and improve student satisfaction (Herried, 2010; Chug et al., 2006). Research on student achievement and content retention is lacking in current academic literature; so this study speaks primarily to the lack of evidence that clicker use will increase student achievement and improve content retention.

Interactive questions within a PowerPoint presentation immerse the student in the class (Herried, 2010). The student uses the device to actively answer an interactive question on a PowerPoint screen. The student selects the answer on response keypad. A typical clicker package includes hardware consisting of one radio frequency channel receiver, a clicker, and the downloadable clicker software. The software is typically installed on the classroom computer and on the instructor's office computer. The instructor uses the clicker software and the radio frequency channel receiver to communicate wirelessly with clickers as the hand held device.

Pedagogy of Clickers

Chung et al. (2006) revealed there is a need in undergraduate science classes to switch from a teacher-centered approach in strategy to a more student-centered approach to learning content. Today's student expects technology to be infused within their classes. Like any common cell phone or television remote, clickers are handheld response devices. The very act of using the device reinforces John Dewey's *learning by doing* approach to instruction. Pedagogically, the study's construct variables content retention, engagement, interaction, and overall impression give more credibility to the Mollborn and Hoekstra Clicker Model (2010).

Eric Mazur (Crouch & Mazur, 2001), a physics instructor at Harvard for nearly ten years, reported that, pedagogically, clickers speak to a social constructivist approach to learning as students learn by doing. Collectively, visually identifying the correct or incorrect answers reflected in histograms help students learn better (Herried, 2010). A histogram is a graph showing the distribution of data as class responses. The Chinese proverb that says a picture is worth a thousand words rings true for the clicker histogram as a graphical representation (Herried, 2010). There have been many calls for school reform, but changing the way content has been traditionally taught is still relatively new. There have been visionaries for radical change in school reform. John Dewey advocated for active learning decades ago with his *learning by doing* approach.

Milner-Bolton, Antimirova, and Petrov (2010) agreed that many teachers are aware that traditional lecture teacher-centered approaches are not working. These teachers realize that traditional lectures have limited effectiveness in science classes. Educators understand there is a demand to develop “critical thinking skills” (p. 14). Pedagogically, clickers help students learn more easily and comprehend difficult concepts. Teachers are realizing there is a shift to move away from traditional face-to-face lectures (Herried, 2010). Sokoloff (2010) claimed there is evidence that traditional lectures are ineffective in teaching difficult or hard to understand concepts.

Sokolloff (2010) gave the example of teaching light and optic concepts as ineffective in face-to-face classes without technology. Sokoloff reported a need in education to develop a “major focus on active discovery curricula like real time physics labs” (p. 1). Teachers who incorporate technology like clickers shift face-to-face lectures and rote memorization “to a more open minded and student-centered approach to teaching and learning” (Tormey & Henchy, 2008, p. 305). Perkins and Turpen (2009) reported that “63% of students focused on how clickers made or allowed them to be active”(p. 227). A student commented, “I got custom feedback” (p. 228). This feedback described by the student was directly related clicker use.

Mollborn and Hoekstra’s Pedagogical Model for Clickers

Mollborn and Hoekstra’s Clicker Model addresses “sociological learning goals, including critical thinking and applications of concepts” (Mollborn & Hoekstra, 2010). The Mollborn and Hoekstra Clicker Model uses the technology to enhance student understanding. It provides “opportunities for applied learning” (p. 19). Using this model, the theoretical framework for the study’s construct variables of retention, interaction, engagement, and overall impression are infused “Clicker questions within lecture segments” (p. 20). Using these variables increase grades, lower the dropout rate and increase student overall satisfaction in science classes. The construct variable responses collected are valid and measurable (Somehk & Saunders, 2010; Mollborn & Hoesktra, 2010).

Several question types from Mollborn and Hoekstra's (2010) model were used to develop the study's construct variables. Questions in the form of concept test type questions, open-ended opinion questions, past experience questions and, in college, design-your-own-clicker-questions can be used as an instrument to measure perceptions of clicker use. The first column in Figure 1 shows the learning goal; the second column shows the different question types that can be used to address the learning goals; and the third column provides some sample questions. Mollborn and Hoekstra (2010) used this model to help guide them as they revised their instruction or developed an instrument for measuring the effects of incorporating active learning using clickers (see Figure 1).

Learning Goal	Question Types Addressing It	Sample Questions
Attendance / Participation	All Question Types	
Understanding Course Material	Reading Questions Concept Type Questions	
Critical Thinking about Concepts	Opinion Questions Past Experience Questions Student Designed Questions	Reading Quiz Question: In the reading, what gender combination led to the lowest likelihood of negotiating, as well as a poor evaluation if the job candidate does negotiate? A. Female evaluator, female candidate B. Female evaluator, male candidate C. Male evaluator, female candidate D. There was no difference
Relating Material to real life experiences and data	Demographic Questions Past Experience Questions Student Designed Question	Opinion Question: How much do you personally think cultural factors explain differences in evidence of violent behaviors between men and women? A. Not much at all B. A little C. They are sometimes useful D. They explain most of what we see E. Don’t know/ Other
Critiquing Sociological theories and methods	Demographic Questions Past Experience Questions Student Designed Question Opinion Questions	Past experience question When you were growing up, which of your parents earned the most money? A. Don’t have two opposite sex parents/one B. Dad usually earned a lot more C. Dad usually earned a little more D. Mom usually earned a little more. E. Mom usually earned a lot more.
Improving the Learning Experience	Instant Feedback Questions Reading Quiz Questions Concept like Questions Past Experience Question Opinion Questions	Concept type questions: Does the sex labeling of occupations affect, supply side gender discrimination, demand side discrimination or both? A. Supply side only B. Demand side only C. Neither D. Don’t know/ other

Figure 1. Mollborn and Hoekstra Clicker Model

Somekh and Saunders Theory of Transformative Learning with Technology

Saunders and Somekh (2007) reported that instructional technologies produce digital content and deliver content that builds on prior knowledge. Their study used technology to engage and interact with their students. The way content is now delivered has evolved into a new and different way of teaching (Somekh & Saunders, 2007). Clickers and other digital tools provide powerful learning experiences for both educators and students. Both parties are active and integrated participants in the content (Somekh & Saunders, 2007).

Saunders and Somekh (2007) reasoned they could organize teaching and learning in totally different ways using digital content. For example, they used the internet, compact disks, digital video disks, Blu-rays, global positioning systems, digital imaging, videos, clickers or any other emerging technologies to get the content across to students. Bruff (2009) recommended using reading quizzes with clickers to gain “summative assessments of the student population” (p. 67). To replace traditional Socratic questioning in a lecture based classroom, the reading quizzes with clickers measured prior knowledge. The technique allows the instructor to gauge how well a concept was received before advancing to other content. Bruff (2009) believed clickers give instructors the ability to give immediate feedback and quick formative assessments of individual student learning. Instant results to questions can be conducted interactively, “several times in a single session” (p. 202).

Research on Clickers

Clickers have been in academia for over ten years (Herried, 2010). Herried (2010) indicated that the way science teachers continue to teach face-to-face classes has a direct influence on why schools continue to have high dropout rates and low enrollments in science and math classes. Herried suggested that if educators change the way face-to-face lectures are being taught in the sciences classes, high dropout rates and low enrollments would improve. According to Herried (2010) and Bruff (2009), clickers are used successfully at The University of Ohio, Harvard, The University of Tennessee, The University of Colorado, New York University and Vanderbilt University.

Herried (2010) reported that clickers are an excellent class equalizer. For example, the shy student can respond without embarrassment. When using clickers, the student suffers no negative exposure from answering questions incorrectly as his or her responses are anonymous (Herried, 2010). However, the student who answers correctly is assured immediately that he or she understands what is being taught in class regarding the instructor's content or concepts. The opposite can also be inferred if the student does not select the correct answer; the feedback although negative is helpful as a visual cue that more study is needed. Clickers increase attendance (Herried, 2010). They produce immediate feedback which is key to expert instruction (Herried, 2010). Furthermore, Herried (2010) found that when clickers are used, student performance and critical thinking skills improved, and content retention and grades increased.

From reviewing prior control groups, Watkins and Sabella (2008) contended that clickers "help students construct learning" (p. 223). Research has shown clickers assist instructors in accomplishing goals (Bransford, Brown, & Cocking, 2000; Herried, 2010). Robinson and Sevian (2011) estimated "more than a million clickers are used in colleges and high schools" (p. 14). They also implied that it is becoming the norm to use clickers in large science lectures, but also advocated for the use of the devices in small classes as well.

An Interactive Learning Demonstration (ILD) is a learning strategy Sokoloff (2010) used with clickers in his physics classes. Sokoloff created his lectures to be student-centered and interactive using the following steps. First, a demonstration of the activity is presented to the class without results, and students are asked to predict the answer. Then, they complete a short "meta-narrative" (p. 20) about a specific concept. The technique allows students to "link concepts" (p. 21). The instructor then has the students discuss their answers in groups. Finally, the students are asked to submit their answers using clickers. The clicker responses are represented as a histogram in a graphical depiction to the class (Sokoloff, 2010).

According to Sokoloff (2010), this process worked well to reinforce his content. Sokoloff stated, "It appears that the use of clickers for our students to record their predictions brings about substantial conceptual learning gains" (p. 19). By pressing an interactive button, clickers allowed students to think more critically as they learned by doing (Bruff¸ 2010). David Anderson (Clicker Pedagogy, n. d.) used clickers in his general and organic chemistry courses at University of Colorado. Overall, Anderson reports clicker use as a success and contends that now he creates interactive slides specifically to be more student centered. Anderson reported that in his general chemistry class that, 98% of the class felt they received a deeper conceptual understanding of the content. He reported an 82% increase in grades on exams (Clicker Pedagogy, n. d.). There is plenty of research to suggest that students enjoy the use of clickers, but research is scant that would confirm Anderson's experience that the device delivers better grades and increases content retention.

Milner-Bolton, Antimirova, and Petrov (2010) argued many educators understand that change is needed in the way we traditionally instruct our students, and they try to incorporate active learning and student-centered strategies with clickers in their curricula. Some textbook publishers already have interactive questions available as electronic resources. If instructors need to analyze, save, sort, or view who specifically answered any question, they can buy matching device IDs on clickers with names registered in any course management system.

However, the genius of the technology is that in real time, students remain anonymous in the class histogram. Although there is scant statistical evidence quantitatively to support that Clickers increase grades and content retention, there is an overwhelming amount of qualitative research strongly suggesting these things happen.

Research shows that using clickers can improve "student performance and promote cognitive engagement" (Robinson & Savian, 2011, p. 18). Sokoloff's approach using the ILD model as a teaching strategy was tested at a large university in the Midwest in a "large algebra-trigonometry based general physics class" (Sokoloff, 2010, p. 19). Using clickers within the subject matter had a positive influence on his class. Sokoloff reported that his students scored higher on assessments. Sokoloff reported "a learning gain of 59% on questions, 57% on ray diagrams and short answer questions, and 76% of the students sketching the rays correctly on a posttest" (p. 19). Unfortunately, Sokoloff did not provide more statistically significant evidence of learning gains, other than in percentages. The study appeared to be more qualitative, with no hard statistically significant differences in the learning outcomes on concepts because of the use of clickers.

Kevin Pollock, professor of physics at the University of Colorado at Boulder, uses clickers as a peer instruction (PI) tool (Bruff, 2009). Bruff suggested when using the PI technique that, educators refrain from giving students the answer or commenting on important concepts until students have had time to discuss these concepts among themselves (p. 14). Bruff reported that the instructor uses PI when his students are tied "between one possible answer" (p. 14). A few minutes for discussion is allowed and then he re-polls the class. This strategy works with students to collaborate and determine the correct answer. This activity of opening another interactive poll of the same question helps to reinforce learning (Bruff, 2009). In this example, clickers foster higher levels of critical thinking skills (Bruff, 2009).

Bruff (2009) revealed that clickers reassure students that they have understood new content before leaving the class. Bruff uses clickers as “homework quizzes” (p. 67). He gives homework at the end of class. Then, the next time the class meets, he quizzes them with clickers on the homework. Keller Finkelstein, Perkins, Turpen and Dubson (2007) implied that discussion is generated successfully because of interactive slides, histograms, and clicker devices. Keller et al. (2007) suggested combining clickers with PI. Discussion amongst peers improves student satisfaction and participation as opposed to students just listening passively.

Keller et al. (2007) found a strong correlation between peer discussion and lecture and attitudes toward student satisfaction. For example, there was a 66% average of students who favored the use of clickers in class where instructors encouraged student discussion. This is fantastic news for researchers looking for good literature on student surveys but there is still little evidence that clickers increase grades or content retention. According to Wolter, Lundeberg, Kang, and Herried (2011), clickers help large classes produce peer interactions.

Lee Gibson (I Clicker, n. d.), Mathematics Professor at the University of Louisville, reported that dropout rates decreased by 30% in his algebra class, and attendance increased to 83% when he used clickers. Herried’s (2010) students believed clickers reinforced his content. McLaughlin (2008) implied that using clickers targets misconceptions and helps to identify misunderstandings on content or concepts. Ribbens (2007) developed a “richer set of data, exploring the mastery of the content” (p. 62). Ribbens stated, “I pushed students to make predictions, and we’d explore further. I’d put up a graph, and ask them to make predictions; I’d tell them a theory and ask them to make predictions” (p. 62). Clickers became Ribben’s main instructional tool. His class "got better grades" (p. 62). Ribbens offered "the same number of D's and F's, and only a few more A's, but the large soft middle of my course developed a new tone and bulged up from C's to B's" (p. 62).

Using data from a control group without clickers in his classes, Ribbens (2007) noted a 20% higher increase in attendance in his biology class. He reported that in his 9:00a.m. class, there were no students sleeping. Ribbens stated, "I'd put up a question, the class would hush as students read through the question and entered an answer. First one or two, then a steady stream" (p. 61). He noted that the histograms were great visual aids for both him and his students. Ribbens stated in response to one question, "95% of you got this one right, good! We don't need to review it, so let's move on" (p. 61).

Effects on Student Achievement

Herried's (2010) study gives credibility to clickers for educators considering changing the way they teach. Herried's students believed clickers helped them prepare for exams and indicated that clickers are useful over traditional lectures in science classes. Somekh and Saunders (2007) agreed that when given choices and alternative resources of content to study, students are more motivated to study. Somekh and Saunders believed students who use digital devices like clickers are motivated to study actively within great PowerPoint lectures (2007). Herried believed face-to-face teaching is boring to the 21st century student and face-to-face formats lack modern teaching strategies like incorporating technology within curriculum (Herried, 2010). Herried believed clickers create a better learning and teaching environment in the classroom.

Kathleen McKinney used clickers as an active learning strategy to ensure students participate in her classes. Her "students do more than simply listen to a lecture" (McKinney, Center for Innovative Teaching and Learning, 2011). McKinney's active teaching strategy allows students to investigate, analyze, process and apply content in nursing concepts. Her students think critically about concepts and become immersed within her curricula. According to McKinney, active learning with clickers should be incorporated starting in kindergarten and progressing into the graduate level.

Effects on Content Retention

Unfortunately, Chung et al. (2006) reported that "current instructional practices in the science fields continue to rely on traditional lectures" (p. 5). They contended that at least "83% of instructors use the traditional face-to-face lecture as their primary method of instruction" (p. 5). Convincing educators that altering their teaching strategies with clickers will improve their classes is not an easy task. The reluctance from teaching faculty to embrace clickers is an issue that must be addressed or the current trend of teaching face-to-face with no interactivity in science classes will not change (Bruff, 2009).

Somehk and Saunder's Theory of Transformative Learning argued that engagement increases active learning. Although no statistical evidence for the claim was presented in their article, Crouch and Mazur (2001) asserted clickers improve grades, increase content retention, and increase student satisfaction. Active learning with clickers helps students "process material, gives them a better understanding of the concepts and great reviews of material" (McKinney, CILT, 2011).

Somekh and Saunders (2007) reported content retention increases with clickers. Wolter, Lundeberg, Kang, and Herried (2011) agreed that students who actively participate in class learn better. Wolter et al. (2011) revealed that when students are involved with the curriculum, they are more inclined to make connections between prior knowledge and new content, thus progressively building on past knowledge. Caldwell (2007) revealed that in her math class when clickers were used, her students showed an increase in A's by nearly 5%, a decrease in the dropout rate by almost 4%, and a decrease in both students who made D's and F's.

Ribbens (2007) reported "students averaged about 8% higher scores and believed they learned the material better" (p. 62). Ribbens revealed that as clickers are embedded within content, students discover how to think a problem through. Gachago (2008) mentioned benefits of the use of clickers such as improving interaction between students and instructors, providing immediate feedback for students and teachers, revealing concepts that were not well received, and helping students understand hard concepts more easily. McCune's (2009) study reports one faculty member stating "new students sometimes are not very good at judging how well their learning is going" (p. 1) McCune found that "there was statistically significant improvement on parts of assessments where clickers were used" (p. 1).

McCune's work further implied that some standardized exams increased grade points when clickers were used. Herried (2010) and Bruff (2009) both agreed that the use of clickers aids in helping students retain content on specific concepts, especially hard to learn concepts in the math and sciences. Clickers work as a tool that alerts the instructor of understanding or misunderstanding on difficult concepts (Bruff, 2009). Bruff gave the following example: If a science instructor knows that 90% of the students answer a question correctly, he or she can move on to the next topic. The instructor can encourage the other 10% who answered incorrectly "to come for an office visit for additional help" (p. 40).

Using clickers appears to build on previous "knowledge during class" (Bruff, 2009, p. 226). So, Bruff implied that if only 20% of the class answered a question correctly, the instructor immediately knew the subject matter covered was not well-received by a majority of the class.

In this case, more discussion on that content is important to at least 80% of the class. These observations can be seen by the instructor and class in the clicker histogram in real time. Tormey and Henchy (2008) reported evidence to suggest “students learn more when they actively engage with the material, the lecturer and the classmates” (p. 304).

Bruff (2009), Herried (2010), and Tormey and Henchy (2008) all believed that clickers were devices that enabled students to learn more easily. More importantly, clickers allowed students to determine if they understood concepts correctly. Even though every student in Martyn’s (2007) class used clickers and perceived them as being helpful and making them more successful in class, the mean score in the class that used discussion scored higher than her class that integrated clickers.

Effect on Student Interaction

According to Herried (2010), attendance in his class without clickers was at 50% to 60%, but when clickers were used, attendance increased to 80%. In their study, Adams and Howard (2009) argued that teachers should use clickers to change the way they traditionally teach from traditional lecture to a more interactive approach to learning. Mazur and Crouch (2001) believed the histogram visually indicated a direct relationship between immediate feedback for instructors and students alike. After using clickers, Caldwell (2007) noticed an “increase in student participation in class” (p. 13). McLaughlin (2008) revealed that students were enthused with the instructional tool “just from the use of the gizmos” (p. 10). McLaughlin suggested if teachers challenged students to think interactively with your content, active engagement within curriculum will occur.

Steinberg (2010) reported that when students used clickers, they had to read more and pay closer attention. Clickers reinforced content as they learned. He believed that student voices were seen actively as histograms. Bruff (2009) also reported that clicker use "makes it easier for students to express minority perspectives" (p. 198). Clickers helped students talk more openly about difficult concepts (Milner-Bolton, Antimirova & Petro, 2010). Bruff (2009) revealed that students are more able to express "themselves confidentially, which encourages them to state their true opinions and beliefs about controversial topics" (p. 199). Bruff (2009) added "clickers enable instructors to collect information on students quickly, easily, and simultaneously" (p. 202).

Adams and Howard (2009) reported that assessments are returned to students faster with clickers as opposed to the slower feedback with paper-based testing. Unfortunately, the paper-based feedback method is still used today. According to a student, the immediate feedback visually in the histograms was excellent and extremely helpful (Milner-Bolton, Antimirova & Petro, 2010). Another student suggested, "use clickers for every class, the more the better" (Milner, Bolton, Antimirova & Petro, 2010, p. 16).

In one of the interviews from Milner-Bolton, Antimirova, and Petro's (2010) study, a teacher implied that she would continue using clickers because they made the class more entertaining. Another student said clickers should be used in every classroom beyond the first year because they get you ready for tests and help you achieve a better grade. Milner-Bolton, Antimirova, and Petro (2010) thus concluded that clickers provided "immediate real-time feedback to students, even in the largest lecture hall and directly influenced student learning" (p. 14). Bruff (2009) believed using clickers interactively engaged his students on particularly difficult concepts. Bruff (2009) argued using clickers in a teaching strategy generates discussions, reveals student learning or misconceptions, and gives immediate feedback.

Effects on Student Engagement

Class engagement occurs as responses are represented collectively on a histogram. A student's voice is represented numerically in bar charts, graphs, or as percentages of the class. According to Herried (2010), the histogram gave the student and the instructor immediate feedback on what content has been retained. Somehk and Saunder (2010) and Crouch and Mazur (2001) both argued that clickers promote John Dewey's *learning by doing* approach for effective instruction. Herried's (2010) study of 6,000 classmates in over 60 different *Introduction to Physics* courses found that classes using clickers out performed classes with only face-to-face traditional lectures. Unfortunately, no numerical data was included to quantify his claims.

According to Caldwell (2007), when teachers alter their face-to-face lectures and create interactive slides associated with clickers, then student outcomes will improve, and content retention and student satisfaction will increase in difficult science classes. Bruff (2009) believed that clickers gave students an investment in answering questions. McKeachie (1998) disclosed to increase grades, students should be actively involved during lectures. Chung et al. (2006) reported that learning was encouraged as students actively participated. Fifty percent of students surveyed believed using clickers helped them master content (Wolter, Lundeberg, Kang, & Herried, 2011).

While using clickers, all students participate digitally, whereas Koening (2010) reported that of the same students only two or three participated verbally. Now, in general his traditional classroom dynamic has changed in that all students participate, not just a few. Mollborn and Hoekstra (2010) regarded clickers as a major tool that helped students participate. Mollborn and Hoekstra (2010) believed clickers engaged and forced pupils to think more critically about the concepts they were attempting to understand. Clickers challenged the passive students' expectations of class (Duncan, 2005). According to Blair, clickers transformed "students from passive recipients to motivated participants through more contextualized, hands-on teaching activities" (Using Active Technology, n.d.).

Kenwright (2009) from the Clinical Laboratory Science Department at the University of Tennessee used histograms to determine whether her students comprehend prior knowledge. Only then did Kenwright (2009) move forward in her lectures. Kenwright (2009) liked the immediate feedback. She used the interactive events generated with clickers as teachable moments for many of her students. For example, "if 80% of the class answered a question correctly, the other 20% who answered incorrectly would now be more motivated to study" (p. 74). The histogram showed 20% of the class that more study is needed.

Because of clickers, a relationship between the student and the teacher occurred in the lecture (Herried, 2010). Herried's work claimed that clickers reversed the negative effects in his face-to-face lectures. Herried altered his lectures to be more student-centered. Herried's (2010) less teacher-centered approach to learning made his lectures more entertaining and interactive for students. Today's young people love interactive games like Xbox or WII and anything that can be loaded on a Smart Phone, from applications to contests. Clickers are game-like devices similar to what students already own today. Bruff (2009) revealed, "There is something about pressing a button on a clicker that lowers the barrier between students and the instructor" (p. 198), and further, "Students are usually more engaged with a task when they are asked to produce a deliverable – an outcome, result, or product that demonstrates their learning" (p. 199). Bruff argued that clickers allow students to produce "small deliverables several times in a class"

(p. 199). Maximum student engagement occurs when teachers use clickers in their classes (Herried, 2010).

Caldwell (2007) cited, “Physics instructors report that when clicker scores account for 15% or more of the course grade, attendance levels were raised from 80 to 90%” (p. 13). Caldwell believed that clickers “increased the likelihood of active student engagement” (p. 13). Similarly, Steinberg (2010) reported that clickers increased attendance and student attention. In White’s *Organization Behavior* course at Northwestern University, Steinberg (2010) warned that if any of White’s “70 undergraduates are late for class or not paying attention, he would know without having to scan the lecture hall” (p. 14). A fast poll of clicker results showed White how many students were present, how many students were paying attention, and how many students were absent?

Another faculty member implied he would change his teaching strategy and develop interactive slides. He would replace his face-to-face lectures with clickers (Koenig, 2010). The teacher’s subject matter would remain the same; the method of teaching with clickers would be the difference. The Clicker Model delivers a better way of teaching content about difficult to learn subject matter (Koenig, 2010). Teachers have begun to understand that clickers help create a connection between students and hard to learn concepts (Herried, 2010). Developing student-centered content will actively teach students and play a major role in giving them more control over their own learning. Some educators realized clickers improve learning when more control is given over their own learning (Using active learning, n.d.). Content becomes student centered as the student became immersed in the lectures (Using active learning, n.d.). Anonymity with the device reduced peer pressure and gave students the opportunities to respond without others knowing who answered (Bruff, 2009).

Overall Student Impressions

Douglas Duncan (2005), professor of astronomy at the University of Colorado, realized his face-to-face lectures were boring. He changed the way he taught his traditional lectures by creating more interactive slides with clickers. At the beginning of his course he asked his students how many enjoyed taking science classes. Duncan (2005) reported 10% to 15% liked taking science classes. At the end of the semester, he asked the same question and found that 80 to 90% liked taking his astronomy class. A student admitted clickers helped him learn and enjoyed using the device (Milner-Bolton, Antimirov & Petro, 2010).

McLaughlin (2008) reported, "93% of his staff viewed clickers as a useful teaching aid" (p. 10). Koenig (2010) reported that clickers had a profound effect on the way his peers would create their future lessons. In the same study, Koeing (2010) implied that the instructors would now create lectures that were less teacher-centered lectures and more student-centered lectures with interactive clicker questions embedded within their PowerPoint Presentations. Koenig (2010) suggested that if teachers would follow this practice they would see "a positive change in their future instruction with an increased focus on student-centered learning" (p. 48). Adams and Howard (2009) suggested that clickers helped the teacher evaluate what was learned and what was not successfully understood in real time.

Perkins and Turpen (2009) compared clicker courses with traditional lectures and found that "82% of students rated lectures with clickers as more or much more useful for their learning than pure lecture presentation" (p. 227). Koenig (2010) reported that one faculty member would, "In the future, use clickers to track students and those scoring poorly on questions will be asked to come in for extra help” (p. 48). Koening (2010) revealed that if his concept was not well received by the students, he refined his interactive slides. Then, the following semester’s slides should provoke a deeper, more positive understanding of the course content.

Clickers were a “good way to assess a student’s existing knowledge or to activate prior knowledge” (Kenwright, 2009, p. 74). Milner-Bolton, Antimirova, and Petrov (2010) stated “70% of the students recommended the use of clickers” (p. 16). Mollborn and Hoestra (2010) implied these findings as true on most overall student perspectives on generalized surveys. Past student surveys indicated they “believed effective use of technology made abstract or esoteric ideas more concrete” (Robinson & Sevian, 2011, p. 15).

McCune’s (2009) study found significant gains in standardized tests when peer instruction was used with clickers. Unfortunately, McCune’s study does not specifically reveal any evidence that grades or content retention increased on hard to learn concepts; only standardized test scores increased. McCune argued that clickers give teachers and students both “formative feedback” (p. 2). He believed formative feedback allowed both teacher and student to judge how well content was understood. Clickers allowed teachers to proceed with new content or address some topics over again (McCune, 2009). Students appreciated knowing or not knowing if they understood. Histograms produced red flags or alarms regarding whether students understood the content or not (McCune, 2009). Adams and Howard (2009) suggested that clickers gave parents’ feedback on student progress, attendance and potential negative consequences and grades. Adams and Howard (2009) recommended clickers to increase comprehension, customize lesson plans, poll the class, and peer-to-peer teach other students.

Alternatives to Clickers

Mantoro, Auy, Habul, and Khasanah (2010) argued that educators should be more flexible in their choice of audience response devices. Mantoro et al. (2010) suggested allowing students to use alternative formats to respond to interactive questions, such as their laptops, the web, instant messaging, PDA devices, and smart phones. Mantoro et al. (2010) suggested using free open source technology called Survnvote in lieu of expensive clickers. Survnvote's free technology utilized portable devices that students already possess to collect and submit data and give and receive immediate feedback. They implied Survnvote was "used by many users, especially those in the educational environment" (p. 34).

Mantoro et al. (2010) claimed that Survnvote was compatible with PowerPoint and they compared it to clickers. Survnvote "promoted the principles of one-man-one-vote...and provided a more accurate and reliable service" (p. 34). In addition, as VOIP technology advanced, Mantero et al. (2010) claimed this upgrade would be integrated within Survnvote technology. Moreover, Mantoro et al. (2010) claimed Survnvote could display complex mathematical equations. They believed Survnvote could replace more expensive clicker technology in the future.

In summary, a service such as Survnvote was less expensive and more flexible in devices that received responses. A major disadvantage of clickers was that there was only one way to respond: the clicker device must be used. The instructor and student were tethered to the computer by clicker software that was installed on the classroom computer and a radio frequency hardware device that was plugged in the back of the computer. Only then would interaction between the teacher and the student occur.

Theoretical Framework

The theoretical framework for this study on clickers was derived from Mollborn and Hoekstra's (2010) Clicker Model and Somekh and Saunder's (2010) Theory of Transformative Learning. The primary researcher used the Mollborn and Hoekstra (2010) Clicker Model to research the adoption of clickers by faculty. This model was constructed for use in a classroom setting. Further, the Mollborn and Hoekstra (2010) model aligns itself closely with the research questions and target population of this audience. The Mollborn and Hoekstra (2010) Clicker Model encouraged active learners to produce digital content. Students and educators become integrated participants within the content (Caldwell, 2007). The Mollborn and Hoekstra's (2010) Clicker Model helps students retain content by connecting hard to learn concepts. Clickers engage millions of students with interactive questions (Mollborn & Hoekstra, 2010). The study's construct variables collected on the teacher perception survey help determine if clickers allow students to ask deeper questions and provoke higher level critical thinking skills (Mollborn & Hoekstra, 2010). The model's questions increase a student's critical thinking skills on concepts using clicker applied technology.

Somehk and Saunder's (2007) theory and Mollborn and Hoekstra's (2010) model both lend themselves directly to observation, thereby allowing for educators to consider altering their teaching strategies over a period of time. As discussed above, the variable constructs for the study were developed using Somehk and Saunder's theory and the Mollborn and Hoekstra's Clicker Model as reference guides. The variable constructs extracted from this framework were content retention, interaction, engagement, and overall impression. Somehk and Saunder's (2007) contended that these active learning strategies promoted a student-centered environment. They further reported that students learn better when given choices and alternative resources of content to study. Somehk and Saunder's (2010) Theory of Transformative Learning and the

Mollborn and Hoekstra (2010) Clicker Model worked together with teachers and provoked higher level critical thinking skills. The theory and the model were valid tools that changed pedagogical strategies; fostering and encouraging engagement and these techniques "harnessed the power of technology" (p. 183).

Bruff (2009) contended that clickers "allowed instructors to hold students accountable for their participation" (p. 198). There is plenty of evidence that clickers increase attendance in the literature review. There is even just as much evidence in student surveys that students believe clickers help them learn. Unfortunately there is hardly any data to date showing quantitatively or qualitatively that clickers increased grades or improved content retention. More scholarly research is needed on these topics.

Conclusion

In summary, Robinson and Sevian (2011) boasted that clickers increased classroom interactions among instructors, students and peers. The pattern in the research is consistent again and again in that there is plenty of evidence suggesting that clickers increased student interaction, engagement, and attendance but there is little to no evidence that clickers increased grades or improved content retention. Clickers instantly allowed instructors to answer student questions. They allowed everyone to participate in class (Bruff, 2009). As interactive audience response device technology advances, Bruff, once the poster child for clickers, now considers using smart phones and laptops instead of clickers in his class (Center for Learning, 2011). He knows devices like laptops, iPads, iTouches and Smart Phones that students already own can easily replace clickers in the near future.

Traditionally, we know that any school reform comes slowly. It is vitally important that we embrace new teaching strategies that work better from simple technology incorporated within curriculum. Bruff (2009) and Herried (2010) both claimed that if specific interactive slides are created, the educators promoted deeper, more analytical understanding of content or concepts. Clickers were used to "breakup lectures with questions and discussion" (Mollborn & Hoekstra, 2010, p. 19).

Peer discussion played an important role in the social theory of learning as "discussion became part of the interactive questions" (Mollborn & Hoekstra, 2010, p. 19). The devices lent themselves to discussion on topics in class (Tormey & Henchy, 2008). The interactive technology pushed "students to resist resting content with existing classifications by encouraging them to clarify their existing cognitive schemas" (Mollborn & Hoekstra, 2010, p. 20). They helped build on a student's prior knowledge (Bruff, 2009). Clickers built knowledge from past instruction, helped the student ponder questions more deeply and developed higher level thinking skills (Mollborn & Hoekstra, 2010).

CHAPTER III:

METHODOLOGY

Introduction

This chapter presents the methodology of the study. The chapter includes the setting of the study, the purpose of the study and the research questions, details the participants, introduces the survey instrument, and details the methodology used.

Purpose and Research Questions

The purpose of this study was to investigate the effect of clicker use in three higher education science classes. The research questions that drove this study were as follows:

1. Is there a difference in student grades in science courses where one group was taught using traditional lectures and the other group was taught using clickers;
2. What are the teachers' perceptions of using clickers in the classroom;
    a. What are teachers' overall impressions of using clickers in the classroom;
    b. What are teacher perceptions of student engagement in a classroom using clickers;
    c. What are teachers' perceptions of a student's content retention in a classroom using clickers;
    d. What are teachers' perceptions of a student's interaction in a classroom using clickers;

3. What are teachers' perceptions of the benefits of using clickers;

4. What are teachers' perceptions of the challenges encountered when using clickers; and

5. What recommendations do teachers' have for improving clicker use in the classroom?

Design of Study

This study was conducted in two parts. Part one was a causal comparative study based on three science courses taught over two semesters. During the first semester, the instructor used PowerPoint with discussion to engage the students. During the other semester, the instructor used PowerPoint with clickers to engage students. Part one of the study examined whether there was a statistical difference in the classes that used clickers and the classes that did not. Part two used descriptive survey research and explored the perceptions of teachers about the use of clickers.

Description of the Setting

In this study, clickers were used with one group of students and not used with another group of students in three different science courses. The first course was *Civil Engineering 350*. The same professor taught both semesters of *Civil Engineering 350*. The group not using Clickers was taught in the fall 2009 semester. During the non-clicker use semester, the professor lectured for 45 to 50 minutes with PowerPoint. Then the professor asked questions and waited for answers. Only two or three minutes were allowed for answers, as time was limited. The instructor used this same instructional method with each of the two course assignments. The assignments were

1. Assignment 1- Concepts of Space-Mean and Time-Mean Speed; and

2. Assignment 2 - Fundamental Relationship Among the Three Basic Characteristics of Traffic Flow – Flow, Speed, and Density.

The same course was taught in the spring 2011semester using clickers. In the clicker class, the professor shortened her traditional lectures and added interactive slides using clickers to engage her students. The assignments were the same as in the non-clicker course.

The second course was *AY 101: Introduction to Astronomy*. The same professor taught both semesters of *AY 101: Introduction to Astronomy*. The group not using clickers was taught in the spring 2005 semester. Discussion along with the lecture was used with this group. The assignments were

1. Assignment 1- The Sun, Stars, Rate of Speeds, Weightlessness Under the Influence of Gravity;
2. Assignment 2 - Causes of Earth's Seasons, Current Size, Mass, Weight, and Surface;
3. Assignment 3 - X-rays, Travel through Space with Radio Waves, Terrestrial, and Jovian;
4. Assignment 4 - Mercury, Moon and Volcanically Active Planets;
5. Assignment 5 - Black Holes, the Sun, Einstein's Equation; and
6. Assignment 6 - Stars, Distant Galaxies, Dark Matter and Evolution.

The same course was taught in the spring 2006 semester using clickers. In the clicker class, the professor shortened his traditional lecture and added interactive slides using clickers to engage his students. Then, the class discussed the results of the histogram showing the class clicker responses for a few minutes. The assignments were the same as in the non-clicker course.

The third course was *CS 202: Introduction to the Information Highway*. The same professor taught both semesters of *CS 202: Introduction to the Information Highway*. The group not using clickers was taught in the spring 2010 semester. Discussion along with the lecture was used with this group. The assignments were

1. Assignment 1- Building a webpage;
2. Assignment 2 - Creating Hyperlinks with HTML code 4.0;
3. Assignment 3 - Creating Tables and Notepad;
4. Assignment 4 - Creating Image Maps; and
5. Assignment 5 - Evaluation of SharePoint.

The same course was taught in the spring 2011 semester using clickers. In the clicker class, the professor shortened his traditional lecture and added interactive slides using clickers to engage his students. Then, the class discussed the results of the histogram showing the class clicker responses for a few minutes. The assignments were the same as in the non-clicker course.

Participants

The total number of students not using clickers in *Civil Engineering 350* of the spring 2009 semester was 52. The total number of students using clickers in *Civil Engineering 350* of the spring 2011 semester was 56. The total number of students not using clickers in *Astronomy*

101 of the spring 2005 semester was 115. The total number of students using clickers in *Astronomy 101* of the spring 2006 semester was 110. The same instructor taught both sections. The total number of students not using clickers in *Computer Science 202* of the spring 2010 semester was 591. The total number of students using clickers in *Computer Science 202* of the spring 2011 semester was 598. The same instructor taught both sections. The total faculty surveyed was n=64.

Instrumentation

A survey was developed to assess Teacher perspectives on clicker use (see Appendix A). The survey was created using Survey Monkey and its URL was distributed via email to 64 faculty members. The survey was anonymous, with 16 Likert scale questions and four open-ended questions. The Likert scale questions were developed using the Mollborn and Hoekstra (2010) Clicker Model and addressed four constructs: content retention, interaction, engagement, and overall impression. Choices of *Strongly Agree, Agree, Strongly Disagree, Disagree and Not Applicable* were options on the Likert scale. Four open-ended questions on the survey explored teachers' perceptions of clickers, the challenges to using clickers, whether clickers benefits student learning, and finally recommendations for improving how clickers could be used in classes. Table 1 shows the relationship between research constructs, survey questions, and research questions.

Table 1

Map of Research Construct Variables to Survey and Research Questions

Category	Survey Question Numbers	Research Question
Demographics	**SQ 1**: How are you using clickers in the classroom: Hard concepts, Assessments, Attendance, What are other ways? **SQ 2:** What is your subject area and course name/level?	
Content retention examines whether clickers provoke higher level critical thinking skills.	**SQ 17:** Students gain a better understanding of concepts when clickers are used during lecture. **SQ 4**: Clickers improve students critical thinking skills on conceptual ideas in lectures more than with traditional method of teaching. **SQ 8**: Students debate questions about specific concepts better when clickers are used. **SQ 12:** Students are more aware of concepts being taught and think more critically about the content when clickers are used over traditional classroom method.	RQ 2c
Interaction examines whether clickers allow students to ask deeper questions; examines whether clickers successfully facilitate discussions and immersive activities within a classroom lecture.	**SQ 10:** Clickers instant feedback helped me clarify whether students understood concepts or had not understood concepts. **SQ 6**: Assessment of what has been learned is more apparent from the immediate interaction received from clickers. **SQ 18:** Students are more interactive during a lecture when clickers are used than in a traditional lecture. **SQ 3**: Students asked more questions in lectures with clickers than in a traditional lecture. **SQ13:** Students participate more in immersive or collaborative activities in classes with clickers than in a traditional lecture.	RQ 2d
Engagement examines whether clickers facilitate	**SQ 5**: Clickers helped students become more engaged with ideas or concepts in lectures**.** **SQ11:** Students did more than simply press a button on a keypad as discussion occurred more often in class with clickers.	RQ 2b

student and teacher as active participants within the lecture.	**SQ 15:** I learned more from engagement with students using clickers than from feedback from students in traditional classroom.	
Overall impression examines student and teacher satisfaction on using clickers in class lectures.	**SQ 9:** Clickers increase the effectiveness of learning in class as opposed to traditional lecture. **SQ 16:** I would prefer more teachers use clickers in classes. **SQ 7:** I prefer to use clickers to enhance engagement with students in class over a traditional lecture. **SQ 14:** I believe clickers help students learn better than they do with the traditional lecture.	RQ 2a
Open Ended Question: Benefits	**SQ 20**: What are the benefits of teaching with clickers?	RQ 3
Open Ended Question: Benefits	SQ 22: How many semesters have you used clickers?	RQ 3
Open Ended Question: Challenges	**SQ 19**: What challenges did you face when using clickers?	RQ 4
Open Ended Question: Recommendations	**SQ 21:** What recommendations do you have for improving Clicker use in the classroom?	RQ 5

Data Collection

Data collection had two phases: collection of final class grade averages and collection of survey responses. For class averages, the instructors provided the investigator with final averages for students in both semesters. For the survey, a URL was distributed to 64 faculty members. The survey was anonymous and consisted of two demographic questions, sixteen Likert scale questions and four open-ended questions. To be in compliance with the Institutional Review Board, the instructors signed waivers permitting the investigator's use of averages from the science classes. No student names or other identifying information was provided to the investigator or associated with any of the data.

Data Analysis

For Research Question 1**,** the investigator used t-tests and a Mann Whitney U test to determine if there were statistical differences in student grades in clicker vs. Non-clicker classes. For Research Question 2, the responses from the survey were coded and entered into Statistical Package Social Science (SPSS) Version 20.0 to generate a factor analysis, descriptive statistics, percentages, means, and frequencies (Gall, Gall, & Borg; 2007). For Research Questions 3-5**,** the investigator coded the responses to the four open-ended questions and identified themes in the data (Gall et al., 2007, p. 241).

CHAPTER IV:

RESULTS

Introduction

Chapter IV discusses the results of mean comparisons of three undergraduate science classes that used clickers one semester compared to classes that did not use clickers in another semester. It explains the survey results in a factor analysis to identify latent underlying factors (Gall, Gall, & Borg, 2007). Lastly, the chapter presents the analysis of teacher responses to four opened ended questions about their perceptions of clicker use in terms of teaching challenges, benefits, and recommendations when using clickers.

Comparing Clickers vs. Non-Clickers in Civil Engineering 350 Classes

Regarding the Civil Engineering 350 class, a Levene's test for equal variances did not hold true and equal variances were not assumed. Because of the small p-value of .016 (< .05), the null hypothesis was rejected. A Mann Whitney U test was performed and indicated a .00**3** statistical difference between the Clicker and non-Clicker classes (see Appendix D). The statistical significance can be seen in Table 2 below.

Table 2

Hypothesis Test Summary

Null Hypothesis	Test	Significance	Decision
The distribution of Score is the same across categories of Clicker classes.	Independent Samples Mann-Whitney U Test	.003	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Comparing Clickers vs. Non-Clickers in Astronomy 101 Classes

Regarding the *AY 101: Introduction to Astronomy* class, a Shapiro Wilks test for normality indicated that the data were normally distributed. A Levene's test for equal variances was valid with a p-value of .890. Because the p-value was large there was no reason to reject the null hypothesis, concluding the samples had equal variances. A t-test was performed and indicated a significant statistical difference between the clicker and non-clicker classes. The p-value was small 0.000, so the null hypothesis was rejected and it was concluded that the samples did have different means (see Appendix E). The clicker class had a higher mean of 72.3 compared to non-clicker class mean of 60.9 (see Table 3).

Table 3

Mean Scores for Clicker vs. Non-Clicker Classes

Score	Clicker	N	Mean	Std. Deviation	Std. Error Mean
	Yes	102	72.3137	12.84021	1.27137
	No	116	60.9397	13.06392	1.21295

Comparing Clickers vs. Non-Clickers in Computer Science 202 Classes

Regarding the *CS 202: Introduction to the Information Highway* class, a Levene's test for equal variances was .000, therefore the null hypothesis was rejected. A t-test was performed that indicated a significant statistical difference between the clicker and non-clicker classes. The p-value was small, 0.000, so the null hypothesis was rejected and it was concluded that the samples did have different means (see Appendix F). The clicker class had a higher mean of 23.5 compared to non-clicker class mean of 19.3 (see Table 4).

Table 4

Mean Scores for Clicker vs. Non-Clicker Classes

Score	Clicker	N	Mean	Std. Deviation	Std. Error Mean
	Yes	598	23.488963	.7022185	.0287158
	No	591	19.293739	1.6940808	.0696852

Teacher Perceptions

Surveys were sent to 64 teachers, out of which 51 responded for a return response rate of 79%. Out of 51 responses only one survey was unusable because of too many missing values. The survey was statistically measureable according to Babbie (1990) in that a response rate of at least 50% was needed for analysis. The psychometric properties of the items measuring teacher perceptions were examined using item-to-total correlations, followed by factor analysis. The original survey had 16 items. Item-to-total correlations for these items ranged from .174 to .833. Only one item, "clickers instant feedback helped me clarify whether students understood concepts or had not understood concepts," had an item-to-total correlation below .30. This item was dropped (de Vaus, 2004, p. 184). High item-to-total correlations support reliability and also provide evidence of validity for measuring a theoretical construct. The revised instrument consisting of 15 items had a Cronbach alpha coefficient of .95. The closer Cronbach's alpha coefficient is to 1, the greater the internal consistency of the items in the scale (Cronbach's alpha, n.d.). The survey instrument had a very good Cronbach alpha score (>.70). "As a special type of correlation coefficient, Cronbach alpha ranges from 0.00 to 1.00 with values of about .70 indicating adequate internal consistency" (Pyrczak, 1999, p. 66).

The survey responses were then subjected to an exploratory factor analysis using principal components analysis. One factor was extracted, and the solution could not be rotated.

The factor analysis indicated that the instrument measures a single construct, "Satisfaction with use of clickers," rather than the four construct variables theorized: content retention, engagement, interaction and overall impression. This factor explained 61.6% of the variance. The results of the factor analysis are presented in Table 5.

Both internal consistency results and factor analysis results indicate that the 15-item instrument for measuring teacher satisfaction with the use of clickers is reliable and valid. Each item is rated using a Likert-type scale ranging from 1(*strongly disagree*) to 4 (*strongly agree*). Not applicable is coded as 0. Possible scores can range from 0 - 60, with higher scores indicating greater satisfaction with the use of clickers. For the teachers in this study, scores ranged from 11 to 60 (M = 3.17, SD = .767).

Table 5

Survey Items loaded for Factor Analysis

Item	Factor 1
Item 9- Clickers increase the effectiveness of learning in class as opposed to traditional lecture.	0.862
Item 14- I believe clickers help students learn better than they do with the traditional lecture.	0.857
Item 11- Students did more than simply press a button on a keypad as discussion occurred more often in class with clickers.	0.859
Item 15- I learned more from engagement with students using clickers than from feedback from students in traditional classroom.	0.836
Item 12- Students are more aware of concepts being taught and think more critically about the content when clickers are used over traditional classroom method.	0.841
Item 8- Students debate questions about specific concepts better when clickers are used.	0.828
Item 4- Clickers improve students critical thinking skills on conceptual ideas in lectures more than with traditional method of teaching.	0.824

Item	Factor 1
Item 18- Students are more interactive during a lecture when clickers are used than in a traditional lecture.	0.841
Item 5- Clickers helped students become more engaged with ideas or concepts in lectures.	0.760
Item 7- I prefer to use clickers to enhance engagement with students in class over a traditional lecture.	0.761
Item 17- Students gain a better understanding of concepts when clickers are used during lecture.	0.762
Item 3- Students asked more questions in lectures with clickers than in a traditional lecture.	0.767
Item 6- Assessment of what has been learned is more apparent from the immediate interaction received from clickers.	0.724
Item 16- I would prefer more teachers use clickers in classes.	0.678
Item 13- Students participate more in immersive or collaborative activities in classes with clickers than in a traditional lecture.	0.590
Sums of squares of factor loadings	9.241
Variability	61.6%

Challenges to Using Clickers

Eighteen of the fifty-one teachers surveyed responded to the open-ended question regarding challenges to clicker use. Teacher responses were grouped into reoccurring categories identified in the responses in Table 6. Software and hardware issues were the challenges reported most often (n=11).

Table 6

Challenges Reported when Using Clickers

Challenges Reported	Teacher Comments
Software or Hardware Issues (11 comments)	• Clickers was poor software • The process of using clickers was very clunky. Too many steps were involved. The professor said he would have probably responded differently to some of my questions had clickers not been so challenging and downright inconvenient to use. • The mechanics of clicker operations were issues • The setup time is challenging, especially in shared multimedia classrooms where the room is heavily used both before and after my class. • The technology did not always play well with other technologies (e.g., Sympodium, Tegrity) • The technical problems (receiver not getting responses from certain students' transmitters, etc.) • The concept of using a clicker was pedagogically sound. However, the shortcoming is typically the poorly designed and supported software that is provided by clicker providers • At end of fall semester 2011, many of his saved clicker quizzes did not contain data and he lost the quiz results. He used to have problems like this with the old system as well. He is tired of technology breakdown issues and not sure if he should continue with these devices, as my students are not obtaining points for their efforts. One could argue that the educational value alone is worth the money spent on clickers, and he might agree, but the angry student mob (300 vs. 1 professor) makes this point difficult to defend. • Getting the system to work reliably! Problems with the computer, with the receivers, and with individual students not understanding how to utilize their clicker.
Student Distraction Issues (2 comments)	• Students are too distracted by other electronic devices to really pay attention. Plus, the clickers had problems with some frequency, taking too much administrative time. • Waiting for every student to enter a response can cost a lot of class time
Effective Design of Interactive Questions issues (2)	• Putting a lot of thought into designing and writing the questions to make sure that students truly understand the concept and are not just regurgitating information. • Trying to measure everything with T/F or MC questions is difficult.
General Housekeeping Issues (3 comments)	• Batteries are dead. I clicked but did not get credit. I hit the wrong button. The timer was too quick. The timer is too slow, this is boring.... • When students didn't bring them to class

- They didn’t work.

Benefits of Using Clickers

Twenty-five of the fifty-one teachers surveyed responded regarding benefits to using clickers. Teacher responses were grouped into reoccurring categories identified in the responses in Table 7. The two categories indentified were increased interaction (7) and feedback (12).

Table 7

Benefits Reported when using Clickers

Benefits Reported	Teacher Comments
Increased Interaction (7 comments)	• Increased student involvement • Increase in co-operation • Student engagement increased; even with quiet or shy students • Rapid results to the students for quizzes and exams. • Students stay better engaged during class time if they have to respond to questions with their clickers. • Clickers force the students to commit themselves to an answer, then discover whether it's right or not. • More classroom interaction. Students are not afraid to ask questions when it is evident from a clicker question result that many other people also did not understand the material
Feed back (12 comments)	• Clickers gave immediate feedback concerning student retention. • Clickers helps instructors know if the students understood immediately instead of finding out after the test. • The instant feedback from clickers allowed further explanations of some concept/procedure • Clickers immediate feedback about how the students are understanding the concepts was useful. • Rapid input on whether or not students are grasping a concept. • Clickers were a nice method to keep students thinking. It also helps me to see how well students are understanding concepts. It's a nice technique for review. • Rapid results to the students for quizzes and exams. • Feedback was useful to the instructor on whether they have gotten a principle. • Feed back with clickers was useful to the students when they see how long it took them to answer a question compared to the rest of the class. • Clickers for Real-time assessment of students' ability to answer questions based on in-call material as unparalleled • Clickers for Assessment in very large classes. • Clickers allow for much more interaction in my large classroom. It is not uncommon to have 175-250 students in my previous Cell Biology courses. With such a large classroom size clickers allow for efficient and effective real-time assessments.

Recommendations for Using Clickers

Ten of the fifty-one teachers surveyed responded regarding recommendations for using clickers. Teacher responses were grouped into reoccurring categories identified in the responses in Table 8. The category, software and hardware requests, had the most responses (7).

Table 8

Recommendations Reported when Using Clickers

Recommendation Reported	Teacher Comments
Interaction (1 comment)	• More classroom interaction. Students are not afraid to ask questions when it was evident from a clicker question result that many other people also did not understand the material
Mentor Program (1 comment)	• More training
Innovative Research (1 comment)	• Clickers be modified for use in derivations.
Software or Hardware Requests (7 comments)	• Clickers improve their software • Programmers stop software glitches • The process of setting up and using clickers become less complicated and clunky. • Simpler-to-use technology which allows mobile phones, portable computers to act as clickers, with better software for instructors' flexibility. • More care into software design. • The stability increase in the technology. Instructor reported using clickers for years, yet during the last 2 weeks of fall 2011 semester lost his clicker grades and was considering giving up on this technology. • Make the software system integrate more seamlessly, from entering class rosters to the recording the responses.

Using Clickers to Teach Hard Concepts

Ninety-four percent of the respondents reported using clickers to teach hard concepts (see Table 9).

Table 9

Using Clickers to Teach Hard Concepts

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	47	94	94	94
	No	3	6	6	100
	Total	50	100	100	

Using Clickers to Assess Content Retention

Ninety-four percent of the respondents reported using clickers to measure a student's content retention with assessments (see Table 10).

Table 10

Assessments Using Clickers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	42	84	84	84
	No	8	16	16	100
	Total	50	100	100	

Using Clickers to Count Class Attendance

Fifty-four percent of the respondents reported using clickers to count student attendance (see Table 11).

Table 11

Attendance Using Clickers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	27	54	54	54
	No	23	46	46	100
	Total	50	100	100	

Classes Taught Using Clickers

Only 27 of the 50 respondents reported the courses they taught with clickers (see Table 12). Engineering classes were the largest amount of courses being taught (6).

Table 12

Classes Taught Using Clickers and Number of Instructors

Classes Taught	Number of Instructors
Physics I	1
Physics II	1
Chemistry	1
Organic Chemistry II	1
Engineering	6
Introduction to Philosophy I	1
Introduction to Philosophy II	1
History	2
Social Work	1
Intro to Women’s Studies	1
Political Science	1
Computer Science	2
Hearing Science	1
Basic Audiology	1
Cell Biology	1
Anthropology	2
Geology Sustainable Earth	1
Biology	2

Conclusion

In conclusion, the findings in the grade comparisons are consistent in that students perform better in classes with clicker use. The survey data indicated that teachers perceived clickers to be pedagogically sound. The data revealed that faculty use clickers to count attendance, review material for assessment, and use clickers to teach hard concepts and difficult ideas in many disciplines.

CHAPTER V:

DISCUSSION OF RESULTS

Introduction

The purpose of the study was to examine the effect of clicker use in three science courses taught over two semesters (*Civil Engineering 350*, spring 2009 and fall 2011; *Astronomy 101* spring 2005 and spring 2006; *Computer Science 202*, spring 2010 and spring 2011). The study also assessed teachers' perceptions of clicker use.

Student Achievement and Grade Comparisons

In regard to the first research question, was there a difference in overall course grades in science courses where one group was taught using traditional lectures and the other group was taught using clickers, the answers were found to be yes for all three courses. From the t-test, the results show the higher mean score of 72.3 in the *Astronomy 101* class that used clickers as compared to the lower mean score of 60.9 in the *Astronomy 101* class that did not use clickers. Subsequently, there was an 11.4-point difference between the class mean score using clickers and the class mean score that did not use clickers. Equally important, the t-test showed a higher mean score of 23.5 in the *CS 202* class that used clickers as compared to the lower mean score of 19.3 in the *CS 202* class that did not use clickers. Here, there was a 4.2-point difference between the mean class score using clickers and the mean class score that did not use clickers. Lastly, there was a .003 statistical significance in the *Civil Engineering 350* mean score that used clickers as opposed to the *Civil Engineering 350* class course mean that did not use clickers. These increases in course means suggest that teachers should use clickers in their classes.

In summary, students using clickers demonstrated a better understanding of concepts in comparison to students not using clickers in all three undergraduate science classes. These findings regarding student achievement mirror what Herried (2010), Bruff (2011), Mazur and Crouch (2001) and many others argued in that clickers improves student achievement on hard-to-learn concepts or ideas. Eric Mazur (Crouch & Mazur, 2001), who taught physics at Harvard for nearly ten years, correctly observed this when he implied that, pedagogically, clickers spoke to a social constructivist approach to learning as students became active participants in lectures.

Teacher Perceptions

Regarding the four proposed constructs, content retention, engagement, interaction and overall impression, the factor analysis suggested that these constructs are not distinct, separate constructs as measured by the survey instrument. Rather, content retention, engagement, interaction, and overall impression appear to be measurable as a single construct—satisfaction with the use of clickers.

Participants' scores on the instrument indicated satisfaction with the use of clickers. The mean score (M = 3.17) corresponds with the agree category of the scale. This finding supports those of Bruff (2011) who indicated that clickers provoke higher-level critical thinking skills. Similar to Bruff's (2011) findings, the faculty surveyed in this study felt that clickers were tools that improved instruction on difficult concepts or ideas, in many different disciplines. Faculty level of satisfaction with the use of clickers also support the claims of Herried (2010) and Bruff (2009) that clickers aid students in retaining content because students debate questions about specific concepts better when clickers are used. The level of satisfaction with the use of clickers also supports Martyn's (2007) observation that students are more aware of concepts being taught and think more critically about the content when clickers are used.

The findings also correspond with Mollborn and Hoekstra (2010) who reported that students ask more questions in lectures with clickers. To that point, Mollborn and Hoekstra (2010) suggested that students are more interactive during a lecture when clickers are used in unison. Using Somehk and Saunder's (2010) theory of transformative learning, student interaction can be measured via the teacher, students, and interactive clicker technology. The overall satisfaction with clickers suggests that the faculty agreed that students are more interactive during a lecture when clickers were used. Consistent with Bruff (2011) and Herried (2010), the participants' satisfaction with the use of clickers supports a belief that learning is apparent from the immediate interaction received from clickers.

The participants' satisfaction with the use of clickers provides support for Bruff's (2009) finding that clickers increase the effectiveness of learning. The findings also support Bruff (2011) and Herried (2010) who indicated that clickers enhance engagement with students. Much like Milner-Bolton, Antimirova, and Petrov (2010) who believed that clickers helped students learn better, the findings of this study suggest that faculty believe students learn better when clickers are used. Sokoloff (2010) claimed there was evidence that traditional lectures were ineffective in teaching difficult or hard to understand concepts. The survey data supports this claim.

Teacher Perceptions: Challenges, Benefits and Recommendations

The last three survey open-ended questions addressed challenges, benefits, and recommendations from teachers about clicker use.

Challenges

From the teacher responses, their comments regarding challenges faced when using clickers related to software and hardware failures. There were no negative remarks indentified indicating the device was pedagogically flawed. However, teachers complained that the technology was arduous to use at the fundamental level. For example, there were comments that both the software and hardware features of the program failed. Teachers repeatedly recommended that major challenges with using the software and hardware be addressed and improved. One teacher implied that clickers were a hard sale to students if the software crashed or appeared remotely unreliable. Another faculty member commented that as wonderful as the Clicker was as an instructional device, it is useless if the technology was clunky or unreliable when receiving and saving data.

Benefits

McLaughlin (2008) reported that 93% of his staff viewed clickers as a “useful teaching aid” (p. 10). The survey data found that 25 of the 51 teachers believed there were benefits to using clickers. Experts (Herried, 2010; Bruff, 2011; Chung et al. (2006) in the literature review all agree with the survey findings that there are benefits of teaching with clickers. According to comments made on the faculty survey, increased interaction occurs (7) and feedback increases (12) using clickers. The comments were grouped into reoccurring categories identified in the responses.

Recommendations

10 of the 51 teachers surveyed recommended alternative ways of using clickers. The responses were grouped into categories, with software and hardware issues the most reported responses (7). Both the survey findings and Bruff (2009) were consistent with wanting change in the way classes are being taught. Bruff (2009) implies that the reluctance to embrace Clickers is an issue that must be addressed or current trends in teaching strategies will not change. This study's survey cites one faculty member asking for more training in the use of clickers. Chung et

al. (2006) reports that "83% of science educators still teach using the traditional method" (p. 5). In this instance, the survey data identified a mentoring program. The need for more training with clickers could be addressed with mentoring programs or shared resources. Mentoring programs could be used to benefit novice instructors incorporating clickers in their lectures. Perhaps it would be easier for teachers to embrace technology like clickers if they had a resident expert nearby to help them learn to use the tool?

One faculty member recommended that mobile technology start to replace or work alongside of clickers. These comments were identified in the survey's recommendations for improving clicker use in the classroom. Educators are aware that technology must be incorporated in lessons; it is mandated already in state standards. Using technology like clickers speak to this state mandated requirement that technology is incorporated within lesson plans. More to the point, teachers believe that clickers benefit class instruction on hard to learn or difficult concepts in many disciplines. Lastly, there was a recommendation to develop clickers that incorporate derivations in clicker questions; this upgrade could take math classes to a whole new level of instruction.

Implications for Practice

This study found that clicker use influenced student achievement and that teachers believed best practices includes using clickers to help produce positive effects in the classes. These findings have implications for practice in teaching hard concepts in higher education classrooms. They include the following:

(1) Pedagogically, teachers can use clickers to help students learn more easily. Clickers help students comprehend difficult concepts. The new subscale derived from the survey in this study shows that teachers enjoy using clickers. Herried

(2010) and Bruff (2009) both thought, just as many of the faculty surveyed in this study, that students gained a better understanding of concepts when clickers were used;

(2) Bruff (2009) contended that clickers "allowed instructors to hold students accountable for their participation" (p. 198). To that point, faculty who teach with clickers can obtain instant feedback that helps them clarify whether students understand concepts or not. Interactive questions within a PowerPoint Presentation immerse the student in the class. Teachers using clickers know the device engages the student in real time activities (Herried, 2010);

(3) With clickers, students cannot remain passive recipients in the learning arena (Herried, 2010). Clickers place students front-and-center in class and thereby involves them actively in the lecture (Herried, 2010). Faculty use clickers to measure assessment of what has been learned from clickers. This study suggests that using the device to measure a student's understanding of difficult ideas or concepts could be beneficial in all classes. This practice would have faculty using the device to measure concepts taught in class and student achievement would improve;

(4) Students should not remain silent in classes. Teachers know that discussion is a technique that can lend itself to better instruction. Wolter, Lundeberg, Kang, and Herried (2011) claimed that clickers helped produce peer instruction, which is exactly how many of the faculty in this study felt when they agreed that students are more interactive during a lecture when clickers were used. According to

Herried (2010), the real time feedback is an important key to good instruction; and

(5) Peer-to-peer discussion with clickers can be used as a technique to discover new ways of learning difficult concepts. Keller et al. (2007) uses discussion generated from interactive slides, thus mirroring a majority of faculty who agreed that when clickers were used in lectures to teach hard concepts, students thought more critically about the content;

(6) The results of this study showed increased student achievement in classes that used clickers as compared to classes that did not. From these findings, faculty should use clickers in their classes, particularly, in science classes. The survey data revealed that teachers are looking for new ways to teach classes, including developing a clicker library or model to use as a teaching aid for beginning teachers;

(7) Faculty should also consider developing mentoring programs. For example, mentors would be available in the design process to help the new instructor develop interactive questions in lectures. A resident clicker expert would be established in a department to assist educators. The mentor, using the clicker library model or example of a mentor's work, would help beginning teachers devise ways to modify their lectures. This type of mentoring program would be help teachers embrace technology more easily as they approach a change in their teaching styles;

(8) Technical support should be provided for beginning teachers in the classroom. Working together as a team, educators could expedite how others learn to use

clicker technology. The limitations identified in the study found that there were different levels of experience for instructors using clickers. This is more evidence that technical support in the classroom would help instructors at different skills set with technology. This technical support could help instructors nervous or anxious about using an unfamiliar instructional tool;

Implications for Future Research

Implications for research include addressing the following items in future research:

(1) Survey faculty members only during the fall or spring semesters. Many teachers are gone or not working during the summer;

(2) Use grades on specific conceptual class assignments rather than final course grades for comparison across clicker and non-clicker classes; and

(3) Extend the study by examining classes with clickers as the control group and classes using mobile devices as the treatment group. On the whole, this study of three undergraduate sciences classes has shown that students in classes that used clickers perform better than students in classes that do not. The researcher believes the same outcome will occur with other devices similar to clickers serving as the instructional tool.

Conclusion

In summary, this study found that it is possible to improve grades with the use of instructional technologies such as clickers. It is imperative that educational strategies, in science classes particularly, change or continue seeing negative effects of low enrollments and high dropout rates. According to Milner-Bolton, Antimirova, and Petrov (2010), traditional lectures have limited effectiveness in science classes and many teachers are aware that traditional lecture teacher-centered approaches are not working. Educators understand there is a demand to develop "critical thinking skills" (p. 14). Pedagogically, clickers help students learn more easily and comprehend difficult concepts. Teachers are realizing there is a shift to move away from traditional face-to-face lectures (Herried, 2010). The findings of this study illustrated that educators found clickers pedagogically sound and they are actively looking for alternative ways to teach lectures. Further, the study identified mentoring programs and technical support as needed in the classroom when using clickers. These types of programs would provide needed pedagogical support.

Overall, this research found that students in clicker classes performed better than students in non-clicker classes in three different science classes. Up to this point, there was no significant literature showing statistically that these devices improved learning concepts. With this research, academics have a study statistically showing students did better in classes with clickers in three different science courses.

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APPENDIX A – IRB CERTIFICATION LETTER

May 25, 2012

Office for Research

Institutional Review Board for the Protection of Human Subjects

THE UNIVERSITY OF ALABAMA RESEARCH

Sheila Morgan
ELPTS
College of Education
Box 870302

Re: IRB # 12-OR-193: "The Effect of Using Clickers in Higher Education Science Classrooms"

Dear Ms. Morgan,

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. You have also been granted the requested waiver of written documentation of informed consent for the survey participants. Approval has been given under expedited review categories 5 and 7 as outlined below:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your application will expire on May 24, 2013. If the study continues beyond that date, you must complete the IRB Renewal Application. If you modify the application, please complete the Modification of an Approved Protocol form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, please complete the Request for Study Closure (Investigator) form.

Should you need to submit any further correspondence regarding this application, please include the assigned IRB application number.

Good luck with your research.

Sincerely,

358 Rose Administration Building
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Tuscaloosa, Alabama 35487-0127
(205) 348-8461
FAX (205) 348-7189

APPENDIX B - SURVEY INSTRUMENT

Dear Educator,

Thank you taking this short survey. The results will provide me with valuable information for improvements in grade increases, content retention, student satisfaction and overall impression based on your answers in this survey. Educators are not required to submit survey, but it would be highly appreciated.

Thank you for your time and consideration,

Sheila Morgan

1. How are you using Clickers in the classroom: Hard concepts, Assessments, Attendance? What are other ways did you use Clickers?

Hard Concepts, yes or no. [ ]

Assessments, yes or no. [ ]

Attendance, yes or no. [ ]

What other ways did you use Clickers? N/A [ ]

2. What is your subject area and course name/level?

[ ]

*

3. Students asked more questions in lectures with Clickers than in a traditional lecture.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Interaction	○	○	○	○	○

*

4. Clickers improve students critical thinking skills on conceptual ideas in lectures more than with traditional method of teaching.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Content Retention	○	○	○	○	

*

5. Clickers helped students become more engaged with ideas or concepts in lectures.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Engagement		○	○	○	○

*

6. Assessment of what has been learned is more apparent from the immediate interaction received from Clickers.

	Strongly agree	Agree	Disagree	Strongly Disagree	N/A
Interaction		○	○	○	○

*

7. I prefer to use Clickers to enhance engagement with students in class over a traditional lecture.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Overall impression of student and teacher satisfaction	○	○	○	○	○

*

8. Students debate questions about specific concepts better when Clickers are used.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Content Retention		○	○	○	○

*

9. Clickers increase the effectiveness of learning in class as opposed to traditional lecture.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Overall impression of student and teacher satisfaction		○	○	○	

*

10. Clickers instant feedback helped me clarify whether students understood concepts or had not understood concepts.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Interaction		○	○	○	○

11. Students did more than simply press a button on a keypad as discussion occurred more often in class with Clickers.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Engagement		○	○	○	○

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A

12. Students are more aware of concepts being taught and think more critically about the content when Clickers are used over traditional classroom method.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Content Retention	○	○	○	○	○

*

13. Students participate more in immersive or collaborative activities in classes with Clickers than in a traditional lecture.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Interaction	○	○	○	○	○

*

14. I believe Clickers help students learn better than they do with the traditional lecture.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Overall impression of student and teacher satisfaction	○	○	○	○	

*

15. I learned more from engagement with students using Clickers than from feedback from students in traditional classroom.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Engagement	○	○	○	○	◉

*

16. I would prefer more teachers use Clickers in classes.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Overall impression of student and teacher satisfaction	○ *	○	○	○	

*

17. Students gain a better understanding of concepts when Clickers are used during lecture.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Content Retention					

*

18. Students are more interactive during a lecture when Clickers are used than in a traditional lecture.

	Strongly agree	Agree	Disagree	Strongly Disagree	N/A
Interaction	*Students are more interactive during a lecture when Clickers are used than in a traditional	Interaction Agree	Interaction Disagree	Interaction Strongly Disagree	Interaction N/A

19. What challenges did you face when using Clickers?

20. What are the benefits of teaching with Clickers?

21. What recommendations do you have for improving Clicker use in the classroom?

22. How many semesters have you used Clickers?

Done

APPENDIX C - AAHRPP IRB Form

AAHRPP DOCUMENT # 109
THE UNIVERSITY OF ALABAMA
HUMAN RESEARCH PROTECTION PROGRAM
FORM: SIGNATURE ASSURANCE SHEET

Directions: The Principal Investigator (PI) and one other person (Dean, Associate Dean, Chair, Supervising Professor, or departmental designee must sign and submit before application can be reviewed by IRB.

Principal Investigator's Assurance Statement (Student investigators may sign as PI) :
I understand the University of Alabama's policies concerning research involving human subjects and I agree:

1. To comply with all IRB policies, decisions, conditions, and requirements;
2. To accept responsibility for the scientific and ethical conduct of this research study;
3. To obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent/assent form;
4. To report to the IRB in accord with federal, sponsor, university, and IRB policies, any adverse event(s) and/or unanticipated problem(s) involving risks to subjects;
5. To complete continuation, modification, and closure forms on time and to collaborate with IRB monitoring of studies for quality improvement or cause;
6. To notify the Office of Sponsored Programs (OSP) and/or the IRB (when applicable) of the development of any financial interest not already disclosed;
7. To ensure that individuals listed as study personnel have received the mandatory human research protections education;
8. To ensure that individuals listed as study personnel possess the necessary experience for conducting research activities in the role described for this research study.

My signature below also means that I have appropriate facilities and resources for conducting the study.
PI SIGNATURE ______________________ DATE 4/23/2012
NAME TYPED Sheila Morgan
STUDY TITLE The Effect of Using Clickers in Higher Education Science Classrooms

****ALL STUDENT RESEARCH: Supervising Professor's Assurance Statement:**
I certify that I have reviewed this research protocol. I attest to the scientific merit of this study; to the competency of the investigator(s) to conduct the project; that facilities, equipment, and personnel are adequate to conduct the research; that continued guidance will be provided as appropriate, and the study will be closed before student graduation.

NAME TYPED ______________________

***Department Chairperson's/Department Designee's Assurance Statement:**
I certify that I have reviewed this research protocol. I attest to the scientific validity and importance of this study; to the competency of the investigator(s) to conduct the project and their time available for the project; that facilities, equipment, and personnel are adequate to conduct the research; and that continued guidance will be provided as appropriate. When the principal investigator assumes a sponsor function, the investigator is knowledgeable of the additional regulatory requirements of the sponsor and can comply with them.
SIGNATURE DATE ______________
NAME TYPED ______________________
TITLE ______________________

***If the PI is also the department chair, dean, associate dean for research, or equivalent, another research-**

APPENDIX D - T-test Civil Engineering 350

Group Statistics

	Clicker	N	Mean	Std. Deviation	Std. Error Mean
Score	Yes	56	86.6295	14.58112	1.94848
	No	52	75.6923	21.59388	2.99453

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	6.030	.016	3.104	106	.002	10.93716	3.52307	3.95232	17.92200
	Equal variances not assumed			3.061	88.600	.003	10.93716	3.57265	3.83794	18.03637

APPENDIX E -- T-test Astronomy 101

Tests of Normality

	Clicker	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Score	Yes	.057	102	.200*	.985	102	.328
	No	.061	116	.200*	.991	116	.605

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

	Clicker	N	Mean	Std. Deviation	Std. Error Mean
Score	Yes	102	72.3137	12.84021	1.27137
	No	116	60.9397	13.06392	1.21295

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	.019	.890	6.466	216	.000	11.37407	1.75913	7.90682	14.84132
	Equal variances not assumed			6.473	213.322	.000	11.37407	1.75717	7.91043	14.83771

APPENDIX F T-test for Computer Science 202

Group Statistics

	Clicker12	N	Mean	Std. Deviation	Std. Error Mean
Mean	WithClicker	598	23.488963	.7022185	.0287158
	WithoutClicker	591	19.293739	1.6940808	.0696852

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Mean	Equal variances assumed	322.059	.000	55.894	1187	.000	4.1952238	.0750567	4.0479652	4.3424824
	Equal variances not assumed			55.662	785.017	.000	4.1952238	.0753699	4.0472734	4.3431742