Novelty or Knowledge? A Study of Using a Student Response System in Non-Major Biology Courses at a Community College

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NOVELTY OR KNOWLEDGE? A STUDY OF USING A STUDENT RESPONSE SYSTEM IN NON-MAJOR BIOLOGY COURSES AT A COMMUNITY COLLEGE

by

Tasha Herrington Thames

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degrees of Doctor of Philosophy

May 2015
ABSTRACT

NOVELTY OR KNOWLEDGE? A STUDY OF USING A STUDENT RESPONSE SYSTEM IN NON-MAJOR BIOLOGY COURSES AT A COMMUNITY COLLEGE

by Tasha Herrington Thames

May 2015

The advancement in technology integration is laying the groundwork of a paradigm shift in the higher education system (Noonoo, 2011). The National Dropout Prevention Center (n.d.) claims that technology offers some of the best opportunities for presenting instruction to engage students in meaningful education, addressing multiple intelligences, and adjusting to students’ various learning styles. The purpose of this study was to investigate if implementing clicker technology would have a statistically significant difference on student retention and student achievement, while controlling for learning styles, for students in non-major biology courses who were and were not subjected to the technology. This study also sought to identify if students perceived the use of clickers as beneficial to their learning. A quantitative quasi-experimental research design was utilized to determine the significance of differences in pre/posttest achievement scores between students who participated during the fall semester in 2014. Overall, 118 students (n = 118) voluntarily enrolled in the researcher’s fall non-major Biology course at a southern community college. A total of 71 students were assigned to the experimental group who participated in instruction incorporating the ConcepTest Process with clicker technology along with traditional lecture. The remaining 51 students were assigned to the control group who participated in a traditional lecture format with peer instruction embedded.
Statistical analysis revealed the experimental clicker courses did have higher posttest scores than the non-clicker control courses, but this was not significant ($p > .05$). Results also implied that clickers did not statistically help retain students to complete the course. Lastly, the results indicated that there were no significant statistical difference in student’s clicker perception scores between the different learning style preferences.
NOVELTY OR KNOWLEDGE? A STUDY OF USING A STUDENT RESPONSE SYSTEM IN NON-MAJOR BIOLOGY COURSES AT A COMMUNITY COLLEGE

by

Tasha Herrington Thames

A Dissertation
Submitted to the Graduate School of The University of Southern Mississippi in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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May 2015
DEDICATION

I dedicate this work to the memory of my grandparents, Joe and Nettie Webb, who instilled in me my passion for education and life-long learning.

To my parents, Jeff and Sheila Herrington, you picked me up when I fell, carried me when I was too weak, and believed in me when I didn’t.

To my children, Addie, Macie, and Brec. Don’t ever be afraid to dream big dreams. Always chase your goals with determination and steadfast amounts of effort. May you always know that your existence completed mine!
ACKNOWLEDGMENTS

Foremost, I would like to express my sincere gratitude to my chair and advisor, Dr. Sherry Herron. The compassion, support, and respect you offer to all who enter your doors clearly shows your love for teaching and dedication to improve academia, one educator at a time. To your partner in work, Celia Young, thank you for always answering the phone and calming me down during my moments of distress. Your support and willingness to help all students who enter the center does not go unnoticed.

I would like to acknowledge and thank my committee, Dr. Taralynn Hartsell, Dr. J.T. Johnson, Dr. Deborah Booth, and Dr. Rejoice Mudzimiri, who graciously gave of their time and valuable input. Their guidance and expertise has helped me produce a work I am truly proud of.

I would like to acknowledge my best friend and educational warrior, Kimberly Cruise. You allowed me to fill you with my dreams of education and then followed me by signing up and walking the trenches with me. From teaching all day together, carpooling in the RAV, weekly night classes, studying countless hours, stress eating at Crescent City and Mexican Kitchen after tests, completing our Master’s degree and coursework for Ph.D., and simply just living life. I would not have wanted to do this with anyone else. Now for your last leg of the journey. May my completed dissertation encourage you to get back on the horse and complete this last step! We started together and though we may not have finished simultaneously, together we will finish!

I am grateful to my family and friends for the sacrifices each of you made for me, which allowed me to focus on my educational dreams.
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CHAPTER I
INTRODUCTION

As an educator, this researcher’s fundamental goal and obligation is to prepare students to lead productive and prosperous lives within society. According to Jose Antonio Bowen, “the goal of a liberal education is to prepare students for the unknown; because the future they will navigate after they graduate is unknown” (as cited in Hope, 2014, ¶1). Statistically, community colleges are where most students choose to start navigating their liberal education (Choy, 2002). Unfortunately, fewer than half of those students are completing the courses they register for, especially non-science major courses, thus eliminating further matriculation in any science course. Berezow (2014) recently reported the results of a survey that suggests only 28% of American adults qualify as scientifically literate. This could become a national problem because “science and technology act like an amniotic fluid” surrounding every citizen in the modern world (Impey, 2013, p. 354). This gives science educators reason to re-evaluate curriculum, pedagogies, and investigate emerging technologies that can aid in retaining and equipping students with the critical thinking skills and knowledge needed to contribute to a civic society.

The advancement in technology integration is laying the groundwork of a paradigm shift in the higher education system (Noonoo, 2011). Technology may be able to help prepare community colleges to meet the needs of a multifaceted and rapidly changing society. The National Dropout Prevention Center (n.d.) claims that technology offers some of the best opportunities for presenting instruction to engage students in meaningful education, addressing multiple intelligences, and adjusting to students’
various learning styles. Nussbaum-Beach (2008) stated, “Teachers will not be replaced by technology but teachers who don’t use technology will be replaced by those who do” (¶2). Student response systems (SRS), also known as clickers, are one of the advanced technological innovations changing pedagogies of today. The clicker is an individual hand held-device used by students to respond to questions that the instructor posts within a PowerPoint as part of daily lectures or as a review from previous lectures. The student’s anonymous responses are collected and tallied by the instructor’s receiver and can be immediately displayed for reflection or discussion (Caldwell, 2007).

Research shows that environments that encourage and stimulate student participation yield students who are more attentive, motivated, better test performers, engaged, prone to in-depth thinking and reasoning, and likely to have a positive attitude toward learning in general, which could result in increased chances of course retention (Pelton & Pelton, 2006). Clickers, when coupled with strategic pedagogy, can provide opportunities for educators to change the learning environment from a passive abode to an active oasis (Caldwell, 2007). Pedagogies like active learning (Martyn, 2007), peer instruction (Mazur, 1997), conceptest (Mazur, 1996), peer learning (Nicol & Boyle, 2003), question-driven instruction (Beatty, Gerace, Leonard, & Dufresne, 2006), and contingent teaching (Beatty et al., 2006) are seeing promising results when coupled with clickers. The engaging clicker technology has been shown to increase student participation, engagement, and offers anonymity for the passive or introverted learner. Clickers also provide immediate data that allows opportunity for instruction to be modified in real-time to address misconceptions instead of becoming a monotonous, ineffective lecture (Caldwell, 2007; Draper & Brown, 2004).
Kay and LeSage (2009) highlighted the need to investigate whether differences exist in student achievement and retention in courses when clickers are implemented with regard to individual learning styles. This study was designed to address the absence in literature regarding technology’s relationship with learning styles in non-major biology courses. Additionally, past research has revealed data hard to compare when assessing clickers’ effectiveness on increasing retention (Caldwell, 2007; Cue, 1998; Hake, 1998; Jackson & Trees, 2003). The ability to compare is hindered due to differences in defining retention as either cognitive or attrition based. In this study, the word retention is used when referring to attrition.

Statement of the Problem

Mollborn and Hoekstra (2010) reported that many faculty members admittedly struggle to engage students in the learning process. Collective research has confirmed that traditional lecture is no longer sufficient to engage students currently enrolled in college classrooms (Barnes, Marateo, & Ferris, 2007; Chung, Shel, & Kaiser, 2006; Herreid, 2010; Prensky, 2001a). Chung et al. (2006) acknowledged that “current instructional practices in the science fields continue to rely on traditional lecture” (p. 5). The researchers report that 83% of science faculty still use the traditional face-to-face lecture method as their primary mode of instruction (Chung et al., 2006). Freeman et al., (2014) analyzed 225 studies of undergraduate teaching methods in science, technology, engineering, and math (STEM) courses. The study revealed that undergraduate students in classes with traditional lecture are 1.5 times more likely to fail than students in classes that use more stimulating, so-called active learning methods. The results also suggest that active learning leads to increases in examination performance that would raise
average grades by a half a letter, and that failure rates under traditional lecture increase by 55% over the rates observed under active learning. These findings support researchers who have suggested instructors need to learn and adapt to using new technologies, such as clickers, particularly for interactivity and engagement to sustain students’ interest and enhance learning (Chung et al, 2006; Herreid, 2010; Oliver & Goerke, 2007; Prensky, 2001a). This study was designed to determine if implementing clicker technology have a statistical significance on student achievement and student retention in courses that do and do not implement clicker technology.

Purpose of the Study

The purpose of the study was to investigate if implementing clicker technology had a statistically significant difference on student retention and student achievement in community college non-major biology courses. Comparison of performances on identical pretests and posttests were used to measure achievement. Retention was measured by comparing starting enrollment to final enrollment. Experimental group included two courses taught with incorporating the clicker technology. Control group included two courses that were taught using traditional lecture format. Additionally, the study sought to determine if there were significant differences in student achievement when controlling for learning styles. VARK Questionnaire (Fleming, 2011) was utilized to determine students’ learning styles, and the Clicker Use Survey (Pelton, Pelton, & Sanseverino, 2006) was utilized to determine students’ perceptions of clicker usage.
Research Questions

Based upon the literature and the research problem stated, several questions were developed for the purposes of this study. The researcher intended to examine the relationship between (a) using clickers as a form of instructional tool at the college level, (b) the effect of clickers on students’ achievement in non-major biology courses, and (c) whether clickers help reduce attrition in non-major biology courses. The study had one general research question divided into several sub-questions that related more directly to specific factors. The researcher anticipated that the questions would facilitate the collection of data to reveal whether clickers were effective instructional tools.

Overarching Research Question: Does the use of clickers as a technological and instructional tool in community college non-major biology courses affect student achievement and retention?

Specific Research Question One: Are there statistically significant differences in pretest and posttest scores between students, when controlling for learning style, which are and are not subjected to implementation of clicker technology in a non-major biology course?

- Research Hypothesis One: There will be significant difference in pretest and posttest scores between students, when controlling for learning styles, which are and are not subjected to implementation of clicker technology in a non-major biology course.

Specific Research Question Two: Are there statistically significant differences in retention rates between non-major biology courses that do and do not implement clicker technology?
• Research Hypothesis Two: There will be statistically significant differences in retention rates between non-major biology courses that do and do not implement clicker technology.

Specific Research Question Three: Will students of different learning styles differ in their perceptions of implementing clickers, in a non-major biology class, as being beneficial to their learning process?

• Research Hypothesis Three: There will be a statistically significant difference in perception scores between students of different learning styles after implementing clickers in a non-major biology class as beneficial to their learning process.

Definition of Terms

For the purpose of clarity and specificity, the following terms were used operationally in this study:

• **Attainment**- the result of degree or program completion.

• **Clicker technology**- a wireless response system that allows instructors to pose questions and students to respond by using a hand held remote, called a “clicker,” which sends their response to a receiver.

• **Learning style**- educational conditions under which a student is most likely to learn (Stewart & Felicetti, 1992).

• **Net-generation**- people who were born between the years of 1980 and 2000. Also known as Digital Natives, Millennials, and Generation Y (Prensky, 2001a; Tapscott, 2009).
• **Non-traditional student**— students who enter college delayed by at least one year following high school, have dependents, considered a single parent, employed full-time, are financially independent, attend part-time, or do not have a high school diploma (Choy, 2002).

• **Retention**— the act of remaining in an enrolled class until its completion.

• **Traditional teaching**— the flow of information from teacher to student without the opportunity for interaction or engagement.

• **Technology integration**— the process of incorporating technological tools, resources, and practices into the daily routine, work, and management of schools (Choy, 2002).

### Delimitations of the Study

The results from this study were delimited to four sections of non-major biology classes with the same teaching objectives at a southern community college in the fall of 2014. The experimental sections were provided with the clickers for classroom polling. All data collected was obtained during instructional time. Although peer instruction was utilized in both the control and experimental groups, the Eric Mazur’s ConcepTest Process (1996) was the peer instruction clicker model adopted for clicker usage. Lastly, this study was delimited to non-mobile clicker technology. This is due to an in-class electronic device policy the participating college currently employs.

### Assumptions

For the purpose of this study’s procedures, its participants, and research setting, the following assumptions were made:
• Student response systems will operate correctly without complications, ensuring a smooth integration into the classroom.

• Students have minuscule previous experience with student response systems, and thus, the novelty effect may be present and encourage students to participate.

• Both groups were taught identically with the exception of clicker questioning in the experimental and unit review game in the control. Continuity and consistency are ensured because the researcher is the instructor of the sample courses in this study.

• Both groups were subjected to peer instruction that provides students with comparable experiences.

• Students would truthfully and attentively answer all the surveys and questionnaires required in the study, as well as perform their best on examinations in the course of study to assess achievement.

Justification for the Study

Collectively, community colleges operate on a significantly smaller budget than four-year colleges and must be very resourceful and skilled in controlling salaries, equipment, facilities, and other assets to remain competitive (Shelton, Epstein, & Davila, 2012). Traditionally, the appropriation of federal funding for community colleges was allocated by student enrollment; however, there is a change starting to lean toward performance-based assessments. At a southern community college where this study was conducted, retention of students was of most importance to administration and educators, because retention ultimately controlled its funding. The solutions to resolving retention problems are complex, dynamic, and not easily attributed to a narrow set of expounding
factors (Braxton, Hirschy, & McClendon, 2004). Noel, Levitz and Saluri (1985) claim that the relationship between the student and the institution are inseparable; either both succeed or both fail, which calls for all factors to be explored.

President Obama acknowledged during the 2010 White House Summit on Community Colleges that community colleges are at the center of America’s effort to educate citizens to a better economy and the ability to compete globally (Obama, 2010). The paper affirms that student retention will play a vital role in the future of our nation as Americans confront the competition of globalization (Larose, 2010). The open door policy must not be closed with so many students needing access to higher education as ever before 2020 (House, 2010). However, simply leaving the doors open is not enough for nontraditional students, who are currently the majority of the student population in colleges (Choy, 2002).

The summation of over twenty years of research on human learning confirms that learning is active, not a passive process (Bonwell & Eison, 1991; Johnson, Johnson, & Smith, 1998; Sarason & Banbury, 2004). Traditional teaching strategies historically have not provided an active, social environment, and thus, have not been beneficial to students by causing feelings of isolation and a lack of interaction and engagement (Cotner, Fall, Wick, Walker, & Baepler, 2008; Halpin, 1990; Tinto, 1993, 2005). When students become unengaged, retention rates suffer. Retention experts have claimed that the level of integration is one factor that directly affects the decision of students to remain in college or to depart (Tinto, 1975). According to Tinto (1975), founder of Interactionist Theory, the high degree of integration into the social and academic environment
contributes to a greater degree of institutional and goal commitment and, therefore, lowers (Tinto, 2006) dropout rate and increases attainment.

Tinto declared that faculty of community colleges cannot control the characteristics that students bring with them, but they can control how they interact with students (2005). The combined reports from the 2013 Center of Community College Survey of Student Engagement (CCSE) and the 2013 Survey of Entering Student Engagement (SENSE) reported that 21% of students never worked with other students during class, 66% never did so outside of class, 73% have never tutored or taught other students, 84% never used face-to-face tutoring with the instructor or another student, 25% never received quick feedback from an instructor, and 24% never asked for help from an instructor when they were having problems.

Kolk (n.d.), urged educators to teach academics in such a way that embraces both traditional communication skills and new technologies. She continues to suggest that the blending of these strategies empower students to make connections between what they are learning in the classroom to the world outside. The net-generation students highly expect that instructors will utilize technology in academic instruction (Kyei-Blankson, 2009). At this community college, non-major biology courses suffer from lower retention rates due to students’ lack of interest in the subject area and required placement resulting from low science sub-scores on the ACT. Integrating technology, especially clickers, with teaching strategies can provide instructors with a tool to generate engagement, interactive peer learning, and instant feedback (Caldwell, 2007; Kay & LeSage, 2009). According to McClenny, Director of CCSE (2013), when students are
engaged and active participants in their learning, they are more likely to succeed and reach attainment of their educational goals, thus increasing retention.

Effectively integrating new technology, like the clicker, takes time and money. Advantage for instructors and community colleges is to know whether all students of every learning style can benefit from the implementation of clicker technology. This current research study added to the limited literature that existed regarding clicker technology’s influence on learning styles (Kay & LeSage, 2009). Because clicker pedagogy was often recommended on class sizes of 50 or more students, this study also provided results when implementing the technology in smaller class settings (Beatty, 2004; Cotner et al, 2008). Moreover, because the community college where the research resided had an electronic device policy on in-class use, this study offered data on the implementation of non-mobile clicker technology. Lastly, the study provided course retention rates for students who were or were not subjected to clicker technology. The study was theoretically founded on the bases of social constructivism, specifically peer instruction, which also added to the limited literature emphasizing collaborative work in the community college setting. Although, the U.S. National Science Education Standards list collaborative work as a science standard, historically, traditional lecture has not proved to provide a conducive environment for this activity (1996). Therefore, the purpose of this research investigated whether implementing clicker technology as an instructional tool had any effect on student achievement and retention.

Summary

In summary, this chapter addressed a statement of the problem, purpose of the study, identified the research questions, outlined definitions chosen by the investigator as
significant for the research, presented delimitations of the study, provided researcher
assumptions and included a justification for the study. Chapter II provides a review of
literature pertinent to the study and presents information on studies that led to this
research. Chapter III explains the methodology developed for the research, as well as the
instruments and data collection procedures. Chapter IV presents the findings, analysis,
and the interpretation of the data collected. Lastly, Chapter V discusses the
comprehensive conclusions and recommendations consequent from the study.
CHAPTER II
LITERATURE REVIEW

This chapter presents a review of literature pertinent to the study. The review of literature begins with a historical review of the reformation calls in community colleges, the modern demographics of community colleges, and current research of students’ technology ownership and usage. This chapter also presents different types of technology being used in science education and the current research on student response systems while addressing issues such as system components, implementation models, student achievement, attendance and retention, and the changes to the learning environment. The chapter concludes with a theoretical and conceptual framework for which the study is founded.

Reformation Call for Community Colleges

Community College was coined by The President’s Commission on Higher Education in 1946 (Hutcheson, 2002). Appointing this commission marked the first time not only in the 20th century, but in United States history, that a President established a commission for the purposes of analyzing the country’s system of education (Hutcheson, 2002). The commission, also known as The Truman Commission, was appointed by the late President Harry Truman to reexamine the role of higher education in an industrialized, post-war America (Hutcheson, 2002). Because President Truman was the only U.S. president in the 20th century not to graduate from college, this appointment was viewed as atypical. The unprecedented work of the Truman Commission focused attention on education as a channel to fortify the nation and the economy by drawing attention to issues of access, equality, democracy, quality, and relevance (Hutcheson,
Drawing conclusions from the Truman Report, Gilbert and Heller (2010) stated the formation of community colleges should be viewed as schools that were primarily regional in scope, locally controlled, intentionally structured to fit into a statewide system of higher education, and able to oblige the interests of the entire state as well as their particular communities. A paradigm shift in educating Americans soon followed. Gone were the days of only providing education to the elite and open were the doors to educate every citizen, youth, and adult seeking to pursue higher education.

Decades later, commissions have been appointed and recommendations brought forth by President Ronald Reagan’s A Nation at Risk (Bennett, 1998), President George W. Bush’s No Child Left Behind (Behind, 2002), and most recently, in regards to community colleges, President Barrack Obama’s, The White House Summit on Community Colleges (2010). Collectively, the commissions’ fundamental emphases were on making sure that America’s educational system was producing knowledgeable citizens, from childhood to adulthood, meeting the needs of the nation, producing a competitive workforce, and equipping citizens to compete globally (Hutcheson, 2002; House, 2010). President Obama stated Americans have failed to live up to this legacy, especially in higher education (Obama, 2010).

Although spending has more than doubled per student in the last forty years, degree attainment among college students has remained at the same percent since 1970 (Jacobs, 2013). In a time where education has never been more important at driving economic success, the U.S. has globally fallen behind at student attainment and achievement (OECD, 2013). According to the Organization for Economic Cooperation and Development (OECD, 2013), the United States has fallen from 1st to 16th out of 34
developed countries in attaining college degrees in just over a decade. This statistic shows that the education system of America is not keeping up and not able to compete with the rapid expansion of post-secondary degrees in the industrialized world and emerging economies. The statistical results from the 2012 Program for International Student Assessment (PISA) show that the U.S. dropped from 17th to 21st in science and 14th to 17th in reading, falling behind countries like Slovakia, Portugal, and Russia. United States Education Secretary Arne Duncan remarked that the results do not support President Obama’s challenge to lead the world in having the best-educated, most competitive work force in the world by 2020 (Feran, 2012).

Although the U.S. still has one of the most highly educated labor forces in the world, it is quickly losing the advantage. The OECD (2013) affirms that the U.S. is the only country where degree attainment levels among people embarking in the labor market (recent graduates) do not surpass people about to exit the labor market (retirees). The Center on Education and the Workforce of Georgetown University released a report stating that by 2020 there will be 55 million job openings in the U.S. economy; 24 million new jobs with 31 million jobs from retiring baby boomers, infers that 65% of these new jobs will require some type of post-secondary education to qualify for employment (Carnevale, Smith, & Strohl, 2010). At the current rate of attainment in higher education, the U.S. will fall short by 5 million post-secondary workers (OECD, 2013). President Obama (2010) argued in his address at the White House Summit, “We will not fill those jobs or keep those jobs on our shores without the training offered by community colleges” (p. 11). William T. Grant Foundation (1988) published a report stating that the millions of non-college bound and drop-out youth and adults are in danger
of being caught in a massive dilemma that can deny them full participation in our society. Gone are the days of the high school diploma being an adequate passport to the American Dream.

Modern Demographics of Community College

The National Center of Education Statistics (NCES) states that nearly one-half of students seeking higher education choose a community college (2013). Unfortunately, fewer than half, 31%, completed the path they began (NCES, 2013). Boggs (2010), the President and CEO of the American Association of Community Colleges (AACC), believes this could be because community colleges serve a population and provide services as diverse as the nation they reside. The open door policy of community colleges guarantees a diverse demographic by offering every adult regardless of age, sex, socioeconomic status, ethnic origin, race, religion, or disability the opportunity of education. According to the AACC 2014 Fact Sheet (2014), the U.S. is comprised of 1,165 community colleges with a total enrollment of 12.8 million students. The average age of a community college student is 28. Approximately 57% of enrolled students are women. Part-time students make up 60% with the remaining 40% being full-time students. The Aspen Institute (2014) states that 80% of entering students need remediation of at least one or more courses. Complete College America (CCA) (2011) reports that 50% of students work more than 20 hours a week with 25% of community college students working more than 35 hours a week. CCA (2011) reports also depict that 75% of today’s students are juggling some combination of families, job, and school while commuting to class. Average tuition and fees total $3,260 with over 50% of enrollment receiving some type of financial aid.
The services community colleges provide are equally diverse. Community colleges have progressed into comprehensive institutions providing workforce development training, continuing education courses, technical programs, dual enrollment for high school students, academic degrees, online instruction, and serving transit students from colleges or universities. According to McPhail (2009), “community colleges have been challenged with the unique opportunity to educate a successful workforce, bring underserved student populations into the mainstream, move people from welfare to work, and support community and economic development.” (p. 4). Duderstadt (1999) maintains that the United States needs a new educational paradigm in order to provide educational opportunity to such a comprehensive breadth of humanity.

Traditional lecture has proven to be ineffective in engaging today’s students Chung et al., 2006; Herried, 2010). McKeachie (2002) goes as far to say lecturing encourages students to take a passive, non-thinking, informational receiving role. Herreid (2010) states that traditional face-to-face teaching is boring to the 21st century student, also known as the net-generation or digital natives, because it lacks teaching strategies that incorporate technology; a vital part of the digital natives’ entire life. Technology could have the potential to revolutionize the traditional teaching and learning process. Educational institutions must accept that technology will not slow down nor ever disappear (Glazner, 2012). The utmost importance is to consider implementing instructional technologies and investigate the role they play in educating the students of today, who will become the workforce of tomorrow.
Students and Technology

Technology is considered to be one of the top eight driving forces changing higher education today (Futhey, Luce, & Smith, 2010). The 2014 National Assessment of Education Progress (NAEP) Technology and Literacy Framework defines technology as “any modification of the natural world done to fulfill human needs or desires.” (¶1).

Encyclopedia Britannica (2014) defines technology as:

The application of scientific knowledge to the practical aims of human life or to changing and manipulating the human environment; which includes the use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productive. (¶1)

President Obama (2010) stated in his address, during the White House Summit, that one of the guiding factors to economic growth and job creation is recognizing that technology is essential. The International Society for Technology in Education (ISTE) (2014) support President Obama’s claim by listing “preparing students for their future in a competitive global job market” as one of the many benefits of teaching, learning, and leading with technology.

According to Prensky (2001a), who wrote the book Digital Natives, Digital Immigrants, there is a generational difference in the thinking patterns of students who have been immersed in technology since birth and those of earlier generations. The new generation is considered to contain students born after 1980 and have been coined as i-generation (Rosen, 2010), millennials (Martin & Tulgan, 2001), net-generation (Oblinger & Oblinger, 2005), and most common digital natives (Prensky, 2001a). Because of this immersion the actual brain is physically different, said Prensky (2001b). Digital natives
prefer to receive information quickly, rely on communication technologies, and prefer active pedagogies rather than passive ones (Oblinger & Oblinger, 2005). Prensky’s theory is supported by the works of Bajt (2011), Tapscott (2009), Howe and Strauss (2000), Oblinger and Oblinger (2005), and Palfrey and Gasser (2008). However, there is a vast array of research that refutes that there are differences between generational learning characteristics (Lai & Hong, 2014; Margaryan, Littlejohn, & Vojt, 2011; Selwyn, 2009). The evidence found was that digital natives favored social activities (Romeo, Guitert, Sangra, & Bullen, 2013).

Jim Steyer, chief executive of *Common Sense Media*, said, “What you have to understand as a parent is that what happens in the home with media consumption can affect academic achievement” (as cited in Ritchel, 2013, ¶11). Technology has forevermore changed, regardless of generational labels, what we need to learn and the way we learn. Community colleges cannot effectively continue to educate such a diverse student population without assessing which factors students bring with them that could affect achievement, retention, and educational attainment. One of those factors is students’ technology consumption. For the last ten years, the Educause Center for Applied Research (ECAR) has investigated undergraduate students’ perceptions of and usage of technology (Dahlstrom, Walker, & Dziuban, 2013). The research study surveyed over 100,000 undergraduates from more than 250 colleges/universities across 47 states and 14 countries. Summation of the study asserts that students’ relationship with technology is complex (Dahlstrom et al., 2013). This relationship encompasses ownership, usage, perceptions, and connectivity. Because technology is personalized and
students are bringing their devices with them to the classroom, imperative is to evaluate what devices they use and what comes from this use (Dahlstrom et al., 2013).

Ownership

Results from the ECAR 2013 showed student device ownership continued to increase from 2012 to 2013. The study reported that ownership of laptops and smartphones by undergraduate students now surpassed that of the general adult population. Although undergraduates continued to rank laptop ownership (89%) as the most essential to their academic achievement, the dramatic increase in ownership of Internet capable devices like smartphones (76%), e-readers (16%), and tablets (31%) was undeniable (Dahlstrom et al., 2013). Despite an earlier report by ECAR 2011 stating that the majority of undergraduates on average own twelve technological devices such as iPad, netbook, e-reader, DVD player, iPod, printer, web-cam, etc., the results of the 2013 ECAR show that 58% of students now own three or more mobile devices with Internet capability. Ownership in the smaller, more mobile devices seem to be gaining ground. The revolution of Bring Your Own Device (BYOD) has arrived in the educational spectrum (Johnson, 2012).

Use

Joshua Bolkan (2013), a multimedia editor for Campus Technology, released an article discussing the findings of a survey used to evaluate students’ technology usage. Results from 777 students surveyed revealed 86% of students said they text in class, with checking email, using social networks, and surfing the web reporting 68, 66, and 38%, respectively. Remarkably, 80% of students admitted that their use of digital devices could interfere with their learning, but less than 5% claimed the device was a large
distraction. The study also reported students using technology for staying connected, fighting boredom, and doing related classwork at 70, 55, and 49% as some advantages of device use. Some disadvantages listed for device usage were not paying attention, missing instruction, and getting called out by the instructor at 90, 80 and 32%. It is noteworthy that 91% of students do not agree devices should be banned from class (Bolkan, 2013).

A study conducted by Chen and Denoyelles (2013) explored basic access and mobile device use of over 1,000 students, mostly undergraduate (n= 809), at the University of Central Florida. Results indicated, based on ownership, more than half of the students used their mobile device for academic purposes. In particular, with regards to usage for academic purposes, males use mobiles more than females, freshman and sophomores use more than junior and seniors, and students of Asian ethnicity complete more assignments using small mobile devices. A noteworthy negative relationship to mention was GPAs of students were found to be lower with usage of small mobile device compared to e-book readers. To further support this, research conducted at Kent State University compared undergraduate students’ cell phone usage alongside GPAs. Although the instructional design of the study was not constructed to determine cause and effect, the analysis of data exposed cell phone usage was adversely linked to GPA and affirmatively linked to anxiety (Paddock, 2013).

Perceptions

The founding chairman of Qualcomm, Inc., Irwin Jacobs, proclaim “Always on, always connected mobile devices in the hands of students has the potential to dramatically improve educational outcomes” (West, 2013, ¶2). To further substantiate
his comment, students also believe in the potential technology has on education. ECAR (2013) data showed 76% of students surveyed believe technology helped them not only achieve their academic outcomes, but also prepared them for future educational plans. Fifty-four percent of students stated they were more actively involved in classes where instructors incorporate technology (Dahlstrom et al., 2013). Additionally, 61% felt that the technology they manipulated during their classes can sufficiently prepared them for the workplace (Dahlstrom et al., 2013).

Connectivity

There is no doubt the connected age is a product of technology, but there are mixed feelings among students about technology’s ability to connect them to other students, instructors, and the institution (Dahlstrom et al., 2013; Oblinger, 2013). Results from the ECAR 2013 study showed students felt fairly positive on technology’s ability to connect them with instructors and the institution at 60 and 64%, respectively. Although, when comparing 2012 to 2013 results data, students’ usage of technology to connect with other students declined by 5% to 53% (Dahlstrom et al., 2013). The data showed that at a time where students were owning and using more technology than ever, use did not necessarily correlate to their feelings of connection within the academic environment. A possible explanation for declining in student to student connection could be that 60% of students surveyed asserted they preferred to keep their social and academic lives independent of each other (Dahlstrom et al., 2013).

Technology in Education

No secret that technology has unlocked educational boundaries, especially in science. Computers have replaced chalkboards, keyboards have replaced pen and paper,
and the Internet has replaced a physical library with an unlimited virtual one. Advancements in technology have transformed the learning process, for both student and teacher, by providing endless opportunities to facilitate and enhance instruction.

The average science classrooms of today are equipped with information presentation technologies such as computers, digital projectors, interactive whiteboards, and wireless access. These technological tools are being used by instructors to expand the walls of traditional pedagogies toward a more active learning environment. For example, providing opportunities to manipulate standard PowerPoint presentations to include pictures, graphics, and sound that can engage students. Further, technology has open the doors to virtual field trips, dissections, and video streaming that may not be afforded to all students due to schools’ financial constraints. Virtual technologies such as electronic books, podcast, digital libraries, educational games and videos, tutorials, simulations, and probe ware are also essential tools that science instructors use to educate the digital natives of today.

An innovative interactive technological tool being used in college classrooms is the student response systems, also known as clickers. Clickers are an interactive polling device software system that allows the instructor to ask questions during lecture or as a review to assess student knowledge. Emerging research has shown that when using the clicker as a technological tool students are more engaged, motivated, and interactive during the learning process. Furthermore, clicker research has shown increased student achievement and retention, when coupling with strategic pedagogy. This study sought to determine if using the clicker technology, as an interactive instructional tool, would affect student retention and student achievement in non-major biology courses.
Student Response Systems

With the emerging trend of funding for community colleges starting to switch from student enrollment to performance-based, educators are pro-actively seeking ways to increase students’ retention and achievement, thus expectantly, resulting in degree attainment (Dougherty & Reddy, 2013). Technology is considered to be a driving force of change in education because it encourages the use of different pedagogical approaches known to traditional lecture. Clicker technology is one innovation that instructors are implementing and investigating to better understand its implications on changing the learning environment while also improving the learning process (Caldwell, 2007). Research shows that instructors in higher education are turning to clickers as a way to engage and motivate the digital natives occupying today’s classrooms (Caldwell, 2007).

System Components

Clicker technology is an electronic polling system that allows students to respond to multiple choice questions presented in lecture using a keypad similar to that of a TV remote (Caldwell, 2007). The polling system includes computer software, receiver, clicker keypad, and instructor remote. The software is installed on the instructor’s classroom computer that has access to some type of projection capability. The technology must be incorporated with PowerPoint presentations where clicker questions are embedded for pre-lecture or during lecture use. The instructor poses questions and the receiver collects student’s responses immediately and stores the data. Each student’s response data can be anonymously displayed in real time, generally in the form of a histogram. This data provides opportunity for self-assessment by students, reciprocal teaching, assigning of grades, or for research endeavors.
Clicker Implementation Methods

Because of the significant amount of economic investment community colleges incur when introducing new technologies, important is to review research of clicker implementation methods. A study conducted in the science department at McGill University evaluated three different clicker implementation method based on opinions, behaviors, and ideologies of students and instructors (White, Delaney, Syncox, Akerber, & Alters, 2011). The *students pay without incentive* (SPWOI) method required students to buy their own clickers and had no points added to their grades for usage. The *students pay with incentive* (SPWI) method required students to buy their own clickers and 3% to 5% were added to the final grade for usage. Lastly, the *institution pays clicker kit* (IPCK) method that required no purchase, and institution-owed clickers were handed out for daily class use. The study gathered data over two semesters with over 1,000 students surveyed. Behavioral data collected based on student attendance and participation highly supported the SPWI model with 69% and 93%. But, only 20% of instructors picked SPWI as a model choice. The researchers reported cheating, extra time to record grades, and technology failing to work as possible reasons. When comparing models to student opinions the IPCK model was favored by students and instructors 92% and 67%, respectively. This could be explained by data showing that 35% of students said it was not appropriate to link participation grades to clicker usage. The SPWOI model showed no gain in student attendance or participation and received no support from students or instructors in opinion polls. Although many institutions do not have the resources to implement the institution pay model, this research does suggest it is preferred over the two student pay models.
**Clicker Research**

A large collection of scholarly articles reports that clicker implementation has spread throughout the educational community. Clickers’ proven ability to transform the learning environment has garnered support from instructors across every discipline. Although clickers were first incorporated into physics classrooms, studies showed incorporation of clickers spread to other disciplines like nursing (DeBourgh, 2008), engineering (Boyle & Nicol, 2003), English (Cardoso, 2011), biology (Brewer, 2004; Crossgrove & Curran, 2008), computer information systems (Larsgaard, 2011), library sciences (Corcos & Monty, 2008), and psychology (Shaffer & Collura, 2009). With respect to the literature review, implementation of clickers has primarily been researched and documented in large classroom settings with only smaller settings recently emerging (Kay & LeSage, 2009; Smith, Trujillo, & Su, 2011).

A comprehensive literature review conducted by Kay and LeSage (2009) revealed numerous benefits of using clickers. These benefits ranged from increased student engagement, attention, attendance, to student participation, performance, and motivation to name a few. Although benefits have been documented, Kay and LeSage (2009) suggest more research is needed based on the lack of systematic research. Specifically, they suggest more research should be done to identify individuals who might not benefit from using clickers during instruction. Their comprehensive review is relevant to the design of this study because it will focus on the gap in literature in regard to the relationship clickers have on student achievement and retention when controlling for different learning styles.
Effects on Student Achievement

Eighty-three percent of instructors continue to rely on traditional face-to-face lecture as the primary mode of instruction in the field of science (Chung et al., 2006). According to Herreid (2010), face-to-face lecture is uninteresting to digital natives because it does not incorporate technology within its pedagogy. Research focused on implementing technology and the affect it has on student achievement can be frustrating to interpret due to the many terms used by researchers to describe achievement. Hake (1998) found students did not score higher on exams with clicker usage versus no clicker. However, this may be due to the subjective nature of measuring student achievement, the lack of content norms, and the discrepancies among the pedagogies applied (Caldwell, 2007).

The quasi-experimental design research study conducted by Mayer, Stull, DeLeeuw, Almeroth, Bimber, and Chun (2009) compared three groups: clicker usage classes, group questioning pedagogy in non-clicker usage classes, and classes that did not apply the group questioning pedagogy or clicker use. The researchers suggested that when clickers were combined with strategic pedagogies it promotes cognitive processes. While they did warn increase in performance could be due to the novelty affect associated with early implementation of educational technologies, the conclusion of the study indicated that clicker using classes displayed greater gains compared to the other groups. Likewise, results support a distinct correlation between clickers and instructional pedagogy. Not known is whether clicker implementation affects student achievement when compared to learning styles. This study aspires to investigate if learning styles are linked to student achievement in classes that do and do not use clickers.
Effects on Student Attendance and Retention

Retaining students has never been more important for the financial security of community colleges. Student’s attendance obviously plays an essential role in a student’s retention. Current research regarding clickers’ ability to affect attendance and retention remains disputed. Research studies have recognized the use of clickers does increase the rate of attendance if associated with final scores (Burnstein & Lederman, 2006; Caldwell, 2007; Cue, 1998; Greer & Heaney, 2004; Jackson & Trees, 2003; Shapiro, 2009).

According to Burnstein and Lederman (2006), rate of attendance in physics class increased to 80-90% when clicker usage counted for 15% of the final course grade. Increased attendance was also encountered by Caldwell (2007) when assigning only 5% of final grade to usage. Jointly, this research shows that assigning a percentage of a student’s final grade to clicker usage does motivate students to attend class. When students are held accountable for their learning, they are more likely to meet expectations set for them. The research findings of El-Rady (2006) and Preszler, Dawe, Shuster, and Shuster (2007) yielded increased attendance without linking clicker usage to final grades. While some research does support clicker usage increases student attendance, not all students agree that attendance should be required or linked to the cumulative grade (Greer & Heaney, 2004; White, Delaney, Syncox, Akerber, & Alters, 2011). These feelings could be explained by the results of Caldwell’s (2007) research that students were bringing fellow students’ clickers to class in order to earn them credit for unattended classes.

Classes that implemented clickers did show higher retention rates compared to those that did not (Caldwell, 2007). These findings showed that only 4% of students had
dropped out of clicker classes by the final exam, as compared to 8-12% who dropped out by the final exam in classes without clickers (Caldwell, 2007). The unexpected result was the significant decrease in dropout of freshman during the transitional period of the fall semester. Nora and Snyder (2008) proclaim there is vast gap in literature when comparing course completion rates of classes that do and do not use technology. This study aims to help fill in the gap by providing course retention rates for students who are and are not subjected to clicker technology. Likewise, no evidence exists that supports implementing clickers achieves increased attendance of students with different learning styles. According to a study conducted by Zepke, Leach, and Prebble (2006), 25% of students cited that the “course did not suit the way I learn” as an important factor when considering to drop a class. This is important to the current study, because students who possess different learning styles might not find the use of clicker pedagogy relevant to their learning preference, and thus, attendance could suffer. This study seeks to investigate if implementing clicker technology increases retention of students with respect to different learning styles.

Maguire and Maguire’s (2013) study, “Can Clickers Enhance Team Based Learning?” applied the use of clickers in a second year computer science module. The study revealed both positive and negative results. Data conveyed clickers had a dramatic effect on both attendance and engagement when compared to classes that did not use clickers. Also, students failing to take the final exam decreased by 3% that resulted in higher retention. Negative results showed a significant difference with respect to exam performance. The exam failure rate in classes with clicker usage was more than doubled compared to classes without clicker usage. The researchers concluded from follow-up
questionnaires that the group-based pedagogical approach was to blame for the drop in exam performance. Pedagogy aside, the researchers concluded clickers were beneficial in increasing attendance, attention, and engagement.

*Changes to the Learning Environment*

Aoun (ACE, 2014) acknowledges that higher education is currently experiencing a paradigm shift. Aoun claims that new teaching and learning innovations, like technology, possess the ability to help resolve the challenges facing higher education such as retention, graduation rates, and overall attainment. Presently, U.S. leaders are focused on debating policy on managing the cost of college and student debt. Aoun (ACE, 2014) suggests that reassessing how higher education is delivered could produce a more lasting solution to these challenges.

A study conducted by Hoekstra (2008) surveyed the innovation of interactive clickers and their effect on undergraduate students learning. The findings revealed that clickers significantly changed the atmosphere to a social learning environment. Hoekstra’s study concluded that not only did interactions increase among students, but when instructors used clickers as an instructional tool, it encouraged active learning, critical thinking, and problem-based learning among peer cooperative groups. These findings coincided with other research that suggested the benefits of clickers such as higher order thinking, as seen most when combined with instructional pedagogies versus when used as a tool to gain attention (Draper & Brown, 2004; Mayer, 2008; Mayer et al., 2009). According to Corcos and Monty (2008), educators must first ensure a solid pedagogy and then implement technology.
Barbara Davis (1993) author of *Tools for Teaching*, advocates that students learn best when they are active participants in the learning process. According to Guthrie and Carlin (2004) the digital natives occupying the classrooms are extremely interested in learning in an active environment. Active learning is a method of instruction that causes students to actively process and cognitively apply knowledge rather than passively acquire it (Caldwell, 2007). Research shows active learning pedagogies significantly increase student engagement in the learning process of biology courses (Freeman et al., 2007; Walker, Cotner, Baepler, & Decker, 2008). A study conducted by Kreie, Headrick, and Steiner (2007) found that freshmen who participated in team learning environments retained course material significantly more than students who did not.

Briggs and Keyek-Franssen (2010) asserted that formative assessment plays a key role in providing an active, engaging learning environment for students. Furthermore Caldwell (2007) states that accountability, preparation, and feedback are all essential parts of formative assessment. Incorporating clickers as a tool in the learning environment provides instructors with the opportunity to offer such immediate feedback. Also, the anonymity the clicker offers encourages participation of students who otherwise might not be willing to contribute. A study conducted by Trees and Jackson (2007) refutes these claims however, and suggests that the success of clicker implementation strongly hinges on how students respond to the technology. All students might not like an active learning environment, and thus, could suffer from its implementation. This study adds to the current literature and helps fill a gap on how active learning environments affect different learning preferences.
Learning Styles

The emphasis of how a student learns has become a significantly appropriate pedagogical focus because students frequently cite inability to handle coursework as a reason for dropping out of higher education (Hawk & Shah, 2007; Johnson, Rochkind, Ott, & DuPont, 2009). Therefore, knowing student learning styles and technology preferences could help teachers discern the best way to effectively teach students.

Learning style is defined as “the preference or predisposition of an individual to perceive and process information in a particular way or combination of ways” (Sarasin, 1998, p. 3). According to Sadler and Smith (1996), learning style is a distinctive and habitual manner of acquiring knowledge, skills, or attitudes through study or experience, while learning preference is favoring one particular mode of teaching over another. The goal of learning style research is to identify groups of people who use analogous patterns for perceiving and interpreting information and knowledge. Some researcher’s claim that based on this information instructors can tailor instruction to provide a more efficient and effective way to teach all learning styles. This assumption has been shown to influence student academic performance (Kolb & Kolb, 2009; Zhang & Sternberg, 2006).

Pashler, McDaniel, Rohrer, and Bjork (2008) concluded after a comprehensive review of learning style literature there was insignificant evidence that matched instruction with learning styles that produced superior learning. This was probably due to more of a learning preference, rather than a learning style, thus highlighting the need for additional research into how learning styles affect learning. This current study uses the Neil Flemings (2011) Visual, Auditory, Reading/Writing and Kinesthetic (VARK) learning style/preference model to determine each student’s learning style or preference.
To determine the dominant learning style, the VARK model categorizes four main sensory modalities by which students prefer to take in new information: visual, auditory, reading/writing, and kinesthetic. Even though learners use all modalities to receive and learn new information, one mode is often more dominant and preferred. Visual learners learn best by seeing. Graphic displays like pictures, demonstrations, handouts, videos, and diagrams are beneficial to this style. Auditory learners learn best by transferring information by hearing. This learner appreciates formats like lectures, peer discussions, and questioning techniques. Reading and writing learners learn best by taking in information as words. The printed text is of most importance to them. This learner likes to use PowerPoint, rewrite notes, reread notes daily, rewrite ideas, graphs, and diagrams into statements, and practice with multiple choice questions. Kinesthetic learners learn best by doing, touching, and moving. A hands-on experience or manipulation of tools is always preferred. Concentration on learning will be lost without movement or external stimulation.

Using clickers in the instructional setting could prove beneficial to every learning style. They would provide opportunities for kinesthetic learners to manipulate the keypad frequently, visual learners to see pictures and evaluate answers in histograms format, auditory learners to use questioning technique through clicker questions and peer discussion for collective answering, and reading/writing learners to receive subject knowledge through PowerPoint and be assessed by multiple choice questioning. Thus, this research study seeks to determine whether there is any correlation between different learning styles and their relationship to student’s perceptions of the benefit clickers can have toward their learning.
Theoretical Framework

Cognitive research has suggested that a remarkable number of students have learning styles inadequately served by traditional lecturing methods (Michel, Carter, & Varela, 2009). This research shows learning is an active process, not passive, and there is a need, especially in science, to move toward a more student-centered approach to engage learners (Chung et al., 2006). Mabrito and Medley (2008) suggest using a pedagogical model comparable to social constructivist when tackling the unique characteristics of the media-rich net generational students. To substantiate their claims, statistical data affirms that net students prefer social activities for learning (Romero, Guitert, Sangra, & Bullen, 2013).

Social interaction is the foundation of social constructivist theory developed Lev Vygotsky (1978). Vygotsky’s theory proposed that mental concepts cannot fully develop without social interaction and that interaction has substantial impact on understanding. Understanding refers to cognitive development, and that development relies largely on language. According to Vygotsky’s theory, there are three stages of language: inner, egocentric, and social speech. Inner speech focuses on nonverbal expression to guide the thought process, whereas egocentric and social speech are similar in that there is verbal expression for communication. Egocentric is more intellectual and aimed toward oneself. Furthermore, Vygotsky coined the phrase Zone of Proximal Development (ZPD) that describes what children can accomplish independently against what they can accomplish with support from others. Vygotsky believed that collaboration between adults and peers occurring in the ZPD led to higher levels of mental functioning. However, the social constructivist theory does not support traditional lecture instruction whereby it
accentuates the importance of language in cooperative thinking, interactions between peer students and instructor, scaffolding, and guided discovery as they collectively play a key role in successful learning.

Conceptual Framework

The conceptual framework of this study is derived from Eric Mazur, Harvard Physicist, who developed and tested a Peer Instruction (PI) technique known as ConceptTest (Crouch & Mazur, 2001). Permission to use and or manipulate the ConceptTest method and graphics was granted through email communication (Appendix A). PI modifies the traditional lecture method by engaging students through incorporating activities that requires each student to apply the fundamental concepts being presented, and then explain those concepts to their peers. Classroom instruction including the PI technique and clicker technology are divided into a series of short presentations called the ConcepTest. Each concentrates on a main idea and is followed by related conceptual question.

ConceptTest are constructed of conceptual multiple choice questions given approximately every ten to fifteen minutes during instruction to survey students’ understanding of the ideas just presented. PI is founded on the ability to be flexible and adaptable, which is why the following description is used as a template. The typical ConceptTest poses a question followed by a one to two minute lapse where students formulate and report individual answers using clickers to the instructor. Next, for two to four minutes, students discuss their answers with peers sitting around them; the instructor urges students to try to convince each other of the correctness of their own answer by explaining the underlying reasoning. Lastly, the instructor calls an end to discussion,
polls students for their answer again which may have changed based on the discussion, explains the answer, and moves on to the next topic (Crouch, Watkins, Fagen, & Mazur, 2007).

Figure 1. The ConcepTest Process.

Collective research reports the rate of correct answers that increases after peer discussion (Crouch & Mazur, 2001; Knight & Wood, 2005; Mazur, 1997). ConceptTest questions provide students the opportunity to practice solving problems by encouraging students to express their ideas verbally and interact with their peers to provide an explanation. These processes are central to social constructivism. A study conducted by Nicol and Boyle (2003) discovered that 92% of students believed that peer discussion helped them learn, with 82% agreeing that being subjected to the explanation of others facilitated them to cultivate their own understanding. The researchers suggest this is
because students are less intimidated to discuss what they do not understand if they are aware of others struggling to grasp the same concept.

The lack of research in utilizing clickers for low enrollment biology seminar classes encouraged the study by Smith, Trujillo, and Su (2011). The study incorporated peer discussion and clicker usage in a small embryology course at the University of Colorado. The findings revealed that utilizing clickers with peer instruction increased the chance that students will do pre-class readings and provided them an opportunity to share thinking and learning from peers, thus helping instructors engage all students during class.

Research by Lasry, Mazur, and Watkins (2008) was relevant to the current effort because the study compared the effectiveness of implementing PI in introductory physics courses at a community college versus a top tier four-year research institution. Results indicated students taught with PI demonstrate better conceptual learning and similar problem solving abilities than traditionally taught students. Surprisingly, students with less background knowledge subjected to PI gained as much as students with more background knowledge in traditional instruction. Furthermore, when utilizing PI student attrition decreased at both the community college and four-year institution.

This study expands on this research by combining the pedagogy of peer instruction with clicker technology in small non-major biology courses in a community college setting. Research infers that when peer instruction is combined with clickers there is an increase in student engagement, student attendance, and peer learning that leads to student achievement. There is little evidence that students with different learning styles benefit equally from this methodology. This study seeks to determine whether
there is a correlation between student achievement and learning styles when subjected to PI in combination with clicker technology.

Summary

A review of the related literature provided a historical analysis of the call for reformation in educating the American citizen. From the research discussed in this chapter, community colleges were currently educating a drastically different demographic from previous years. An extensive review of literature revealed that current student demographics value technology, and their relationship with it was extremely complex in regards to student use, ownership, perceptions and connectivity. Thus, the challenge for educators was to investigate how to effectively and efficiently incorporate technology into the classroom so that learners of all learning style benefit.

Comprehensive literature reviews on utilizing clickers during instruction had proven to be a promising social constructivist pedagogy. Not only did clickers fulfill the digital native’s longing for incorporating technology during instruction, but also proved beneficial to instructors by providing real time assessment. There was a surplus of research that indicated clickers could change the learning environment from passive to active by increasing student interaction, engagement, attendance, and motivation. But, little to no evidence that students of different learning styles benefit the same in regards to student achievement and retention was made. Comparing research studies based on student achievement and course retention proved difficult due to the subjective parameters individual researchers controlled. This review concluded with the theoretical and conceptual frameworks which directed the design of the study.
The next chapter presents the methodology of performing the current study, its participants, settings, procedures, and forms of data analysis.
CHAPTER III

METHODOLOGY

Introduction

The purpose of this research was to investigate student retention and student achievement of community college non-majors biology students who were and were not subjected to the implementation of clicker technology when controlling for learning styles. In modern society, the use of technology has become routine in everyone’s life. Today’s classroom can be traditional or virtual, and the role of the teacher can be instructor or that of a facilitator. Students today view technology as an integral part of not only their daily life, but also their way of learning (Oblinger & Oblinger, 2005). Studies confirm that courses implementing clicker technology have students with higher levels of participation (Caldwell, 2007; Hinde & Hunt, 2006), attention (Bergtrom, 2006), engagement (Brewer, 2004), improved attendance (Caldwell, 2007; Kay & LeSage, 2009), increased opportunities for interaction with teacher and peers (Trees & Jackson, 2007), and provides immediate, viewable assessment for modifiable instruction (Brewer, 2004; McCabe, 2006). Clickers provide complete anonymity for all learners, those passive and active (Banks, 2006). According to Draper and Brown (2004), the use of clickers provides all students with the opportunity to become active participants of the learning environment without judgment.

Drawing from the purpose of this study, the research questions are as follows:

1. Are there statistically significant differences in pretest and posttest scores between students, when controlling for learning style, which are and are not subjected to implementation of clicker technology in a non-major biology course?
2. Are there statistically significant differences in retention rates between non-major biology courses that do and do not implement clicker technology?

3. Will students of different learning styles differ in their perception of implementing the use of clickers, in a non-major biology class, as being beneficial to their learning process?

Research Design

A quantitative, quasi-experimental research design was utilized to investigate the implementation of clicker technology and its effect on student retention and student achievement in community college non major biology courses, which did and did not use this technology, while controlling for learning styles. Complete randomization was not feasible because students self-select course-time and instructor. For this reason, the non-equivalent group design, a type of quasi-experimental research, was employed. The biology instructor acted as both researcher and instructor. The instructor previously received training in the use of clickers from Turning Technologies. This included how to download the software, activate the clickers, create questions, logging responses, data loading and un-loading, and generating reports. The independent variable in the study was the implementation of clicker technology in the experimental sections by means of utilizing Conceptest clicker questions. The dependent variables included student retention, student achievement (pre/post-test), and student perception of clicker use in the experimental groups, and student retention and student achievement (pre/post-test) in the control groups.
Pilot Study

The researcher conducted a pilot study using the clicker technology prior to the fall 2014 semester. The pilot study aimed to ensure the efficiency of the TurningPoint software, the activation of the clickers, the ease of logging responses, and the researcher’s ability to utilize the technology. Through collaboration with administration, the researcher received permission and utilized the clicker technology during the “Graduation It Matters: 101” session at the fall 2014 Faculty Professional Development, which was held prior to the start of the semester. The Advising Director, who presented the session “Graduation It Matters: 101,” and researcher collectively reviewed the material being presented during this session. The advising director expressed what information was important for all faculty to take away from the session. The researcher formulated the ConcepTest clicker questions on important information, disclosed by the advising director, to poll the faculty. The researcher used the TurningPoint software to embed the questions into the “Graduation It Matters: 101” presentation (see Appendix B).

Approximately, 200 faculty members rotated through the forty-five minute advising session. Upon entering the session faculty members were handed a clicker. The researcher explained that throughout the “Graduation It Matters: 101” presentation questions would be asked to evaluate their understanding of the new graduation requirements. These questions would be embedded into the PowerPoint and needed to be answered by pressing the corresponding letter button on their clickers. The answers to questions would be displayed, in a histogram format, on the whiteboard to evaluate their understanding of the new graduation requirements. Faculty were given the opportunity to ask questions before the session began.
The Advising Director utilized a PowerPoint explaining the changes to graduation policy within the college. During the presentation and after very important changes to graduation requirements were explained and discussed, a PowerPoint slide would follow with clicker questions evaluating the faculty’s understanding. The TurningPoint software collected the clicker question response data and the researcher displayed the histogram on a PowerPoint slide for the presenter. This enabled the presenter to continue if knowledge of the topic was gained, to encourage group discussion, or to review the information with the faculty if the knowledge was not obtained, which was followed by re-polling.

The primary aim of the pilot study was to ensure the efficiency of the TurningPoint software, the activation of the clickers, the ease of logging responses, and the researcher’s ability to utilize the technology. The feedback did not indicate any problems with the researcher utilizing the TurningPoint software nor the clicker technology. The study successfully demonstrated the ease of use when logging response data with the clickers and the software’s ability to provide immediate feedback for use of the presenter.

Participants

Gerring and Zimbardo (2002) define a sample as a subset of a population selected as participants in an experiment. Participants of this study consisted of four course sections of non-major biology students who voluntarily enrolled in the fall 2014 semester at a southern community college. Participants who typically fill this course are non-science majors, athletes, and students who scored below a 16 on their English sub-score on the ACT, those students are required to take this course before gaining access into any other science course. All participants were required to be 18 years or older, thus
foregoing parent/guardian permission. No participant was excluded due to ethnicity, gender, or race. Two sections were designated as the control group with the remaining two sections being the experimental. The experimental and control groups (courses) were randomly selected by pulling a letter E, for experimental, or C, for control, out of an envelope prior to the start of the course. Randomization of participants themselves could not be controlled within each course per se, due to the fact that students self-select course time and instructor.

All four course sections, which included two experimental and two control, were offered during the day as traditional face-to-face instruction, and received the same amount of lecture material, lecture time, quizzes, learning styles questionnaire, peer instruction, and identical pretest-posttest. The only difference between the sections was the implementation of the clicker technology, the administration of the Clicker Use Survey in the experimental sections, and the use of a unit review game in the control sections that controlled for novelty effect.

Population is defined by Gerring and Zimbardo (2002) as the entire set of individuals to which generalizations can be made based on an experimental sample. The population from which the participants were obtained was students enrolling in sections of a non-major biology lecture course at a southern community college. The college offers an Associate of Arts degree in eight academic divisions, Associate of Applied Science technical degrees in nine health science programs, and eighteen career vocational programs that lead to advance certification. The college provides workforce development training, continuing education courses, technical programs, dual enrollment for high school students, online instruction, and serves fugacious students from a college or
university. The college prides itself in being listed in the top 10% of all U.S. community colleges in 2013 and 2015 by the Aspen Institute. The institution is considered to be of medium-sized with fall 2012 enrollment of 5,949. The student population is 75% full-time with 22% enrolled in only distance learning courses and 54% enrolled in some distance learning. Sixty-eight percent of students are Caucasian and 29% are African American. Sixty-one percent are female and 39% are male.

Instrumentation

The researcher deployed numerous instruments for collecting data. The study utilized two separate survey instruments: VARK Questionnaire and Clicker Use Survey. These were based on existing research and used to collect and analyze response data from students who participated in this research.

The first instrument, VARK Questionnaire (Fleming, 1992), was a learning styles indicator (see Appendix C). Permission to use the questionnaire was granted through email communication (see Appendix D). The VARK questionnaire was administered online with specific instructions provided by the developer. The VARK questionnaire was developed by Neil Fleming to provide learners with a profile of their learning preference for intake and output of information. It is comprised of 16 multiple choice questions with four items each corresponding to the four sensory modalities; visual (V), aural (A), reading/writing (R), and kinesthetic (K) (Bernardes & Hanna, 2009). The answers are accumulated by category and the highest score determines the preference modality. If the participant has no clear preference for any one mode or has equally strong preferences for two, three, or four modes, the participant is considered to be multimodal (MM). In the research by Leite, Svinicki, and Shi (2010), the modalities of
the VARK questionnaire were measured through a comparison of four multitrait-multimethod confirmatory factor analysis models, and the results revealed that the correlated trait-correlated method model had the best fit to the VARK scores. The study achieved initial support for the validity of the VARK scores. The researchers were able to establish reliability estimates by performing confirmatory factor analysis. The estimates for the VARK modalities were .85, .82, .84, and .77 for visual, aural, read/write, and kinesthetic modalities, respectively. Because the VARK questionnaire is not used for high-stakes decisions this is considered adequate. The strength of the instrument lies in its educational value for helping people think about their learning in multiple ways and giving them options they might not have considered (Fleming & Baume, 2006). Fleming stated the VARK instrument was not designed to be reliable in consistency of scores over a long period of time, but provided students with effective learning strategies to use based on their learning preferences (Landry, 2011).

The second instrument, The Clicker Use Survey, was developed and validated by Pelton, Pelton, and Sanserverino (2006) (see Appendix E). Permission to use the survey was granted through email communication (see Appendix F). The instrument was developed to assess students’ perception of the use and the utility of clickers in the classroom. The survey contained a demographic section followed by 18 questions evaluating the use of clickers and students’ viewpoints toward them. The following Likert scale was used to judge each question: 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree. Reliability was not reported by Pelton, Pelton, and Sanserverino, but the reliability within this study yielded a Cronbach’s alpha coefficient of .920. Demographical variables important to the researcher were added to
the survey. The variables added were as follows: (a) gender as male or female; (b) educational status as first, second, third, or fourth semester; (c) age categories as 18-23, 24-29, 30-39, or 40 and over; and (d) enrollment status as full time, part time, dual enrolled, or only this class.

The third instrument are the four unit pretests and posttests found in Appendix G were used to measure student achievement (dependent variable). The pretests-posttests were designed by the researcher and submitted to a focus group that included the department chair and four biology instructors to check the clarity of the instrument. The pretest and posttest were comprised of ten multiple choice questions drawn from the test bank of *Inquiry into Life*, 14th edition, published by McGraw Hill, with permission (see Appendix H). The questions were aligned with the learning objectives stated for the course and constructed to assess levels of Bloom’s Taxonomy (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956; Krathwohl, 2002). The pretest scores were compared to the posttest scores to measure achievement gained and also to compare entry level knowledge of the control and experimental groups.

Procedure

After approval was granted from the participating university and community college institutional review board (Appendix I and J), the research began the first day of the fall semester. Students enrolled in the participating sections of non-majors biology courses at a southern community college in the fall of 2014 were verbally informed of the research study by the researcher reading out loud the participation research notification letter (see Appendix K). Students were informed that participation was voluntary and no penalty would come from withdrawing from the study. After explaining and answering
students’ questions about the research study, the students were introduced to the professional associate who would be their point of contact in the research. After the researcher left the classroom, the associate asked students who were willing to participate to sign an informed consent form and collected them (see Appendix L). The associate provided each student with an identification code to ensure confidentiality during the course of the research, and provided associate contact information, in case of lost code retrieval. The students were instructed to use this code on all surveys, pretests, and posttests collected. Only the professional associate had access to the identification codes and kept all forms collected in a locked file cabinet behind a locked door. Electronic data was kept in a password protected file. After the researcher entered the pretests and posttests data by student’s code, the tests were picked up by the professional associate and kept in a locked file cabinet behind a locked door. The professional associate affiliated with this research was the Division Chair of the Health, Physical Education and Recreation Department at the participating community college. The associate has been a certified athletic trainer for twenty-one years and serves on numerous college committees.

*Experimental Group*

Prior to any instruction, students completed the online VARK Learning Styles Questionnaire. Upon completion of the questionnaire, the researcher explained the syllabus and discussed course learning goals. Students were introduced and instructed on the proper use of the clicker technology. The researcher provided the clickers for the duration of the semester each day, thus foregoing any purchase requirement of the
students. Students used the remaining class period to practice using the clickers by answering probing questions about syllabi information.

Students completed a pretest for each of the four units, a posttest for each of the four units, and a clicker use survey. Students picked up a clicker as they entered the classroom each day. At the start of class, students were asked 4-6 ConcepTest clicker questions from the prior lecture. Examples of ConcepTest questions can be found in Appendix M. This assessed retention of material. Lecture of new material was followed with 4-6 Conceptest embedded clicker questions positioned approximately at fifteen minute intervals. The questions were designed to become progressively harder as the semester continued so students were compelled to apply higher order thinking skills. Following each question, the instructor displayed a histogram showing the students’ responses. The instructor chose which remediation was needed, if any, for classes not reaching 75% accuracy. Depending on the percentage of incorrectness, re-teaching or peer instruction was utilized with re-polling of the question that followed. Clicker questions counted as class participation, which was 10% of the student’s final average. Students completed a posttest at the completion of each unit. During the final week of instruction students were administered the Clicker Use Survey. After semester grades were submitted to the college Registrar’s Office, the professional associate provided the researcher with the inform consent forms, pretests, and posttests. Non-participating student data was extracted so that data analysis could begin.

**Control Group**

Prior to any instruction, participants completed the online VARK Learning Styles Questionnaire. Upon completion of the questionnaire, the researcher explained the
syllabus and discussed course learning goals. Students were administered a pretest for each of the four units and a posttest for each of the four units. Lecture material was covered with random breaks for questioning that may have been followed by peer instruction if needed. If remediation was needed the instructor chose the format. In the control group, there was one modification to the instructional design. Students reviewed each unit with a game show type questioning game, used to control for novelty effect. The game was comprised of ConcepTest questions used in the experimental group, but without the use of clickers. After the review, students were administered the same posttest as the experimental group. After the researcher entered the pretest and posttest data, the professional associate picked the test up for storage. The professional associate returned the materials after final grades were submitted to the college Registrar’s office. Non-participating student data was extracted so that data analysis could begin.

**Group Comparison**

The experimental and control groups contained the same learning goals, lecture material, learning style survey, peer instruction, projects, quizzes, unit test, and pretests and posttests. Uniformity was held throughout this design by embedding ConceptTest clicker questions during lecture for the experimental group and during unit review for the control group. Clicker Use Survey was only administered to the experimental group.

**Data Analysis**

The statistical software package SPSS analyzed the data collected. The aim of the study was to determine if the implementation of clicker technology had an effect on student achievement and student retention when controlling for learning styles. Four sections of a non-major biology course located at a southern community college were
included in this study. All four sections, two experimental and two control, received the same amount of lecture material, lecture time, VARK Learning Styles Questionnaire, ConcepTest questions, and pretests and posttests. An appropriate combination of t-tests and repeated measure MANOVA procedures were used to measure student achievement and the relationship between clicker and non-clicker classes. In order to measure retention ratios the researcher utilized the Chi square test for both clicker and non-clicker classes. The experimental group was administered the Clicker Use Survey, given at the end of the semester that was analyzed by ANOVA. After the researcher received approval to conduct research by the Institutional Review Board of the university and community college, collection of data began.

Summary

In summary, this chapter discussed the research design and questions for this study. The researcher provided a thorough description of the population from which the sample was taken. In detail each instrument, procedure, and data analysis tool chosen for this study was explained. Chapter IV provided the results from the data collected. The chapter is divided into two sections: (1) descriptive portion of the findings gathered from the participants, and (2) the findings related to the research questions and hypothesis specifically. Together, they provide a foundation to develop conclusions, implications, and recommendations for further study.
CHAPTER IV
ANALYSIS OF DATA

Introduction

The purpose of this study was to investigate if implementing clicker technology would have a statistical significant difference on student retention and student achievement, while controlling for learning styles, for students in non-major biology courses who were and were not subjected to the technology. This study also sought to identify if students perceived using clickers as beneficial to their learning. Data collection occurred within four non-major biology courses during the fall semester of 2014 at a southern community college. Analysis of data investigated differences in pretest and posttest scores of students in both the experimental (clicker use) and control groups (non-clicker use). Analysis of data also investigated the retention rates of students in non-major biology courses who were and were not subjected to clicker technology. Furthermore, this study sought to determine if students with different learning styles differed in their perception of using clicker technology as being beneficial to their learning process.

Descriptive Findings

Data were first analyzed quantitatively by using descriptive statistics and frequencies. This study included 118 participants (N= 118). Table 1 shows a representation of the demographic characteristic of the participants based on gender between the clicker and non-clicker courses. The majority of the participants were females (63.6 %). The clicker group were composed of 41 females (60.3%) and 27 males...
The non-clicker group were composed of 34 females (68%) and 16 males (32%).

Table 1

*Frequency Statistics of Gender by Group (n=118)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Clicker Count</th>
<th>Non-Clicker Count</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>27</td>
<td>39.7</td>
<td>16</td>
</tr>
<tr>
<td>Female</td>
<td>41</td>
<td>60.3</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>100%</td>
<td>50</td>
</tr>
</tbody>
</table>

Demographic characteristics of the participants based on status, age category, and enrollment for the clicker group are depicted in Table 2 (n=68). These demographic variables were not collected from the non-clicker group. The status distribution included 42 participants who were in their 1\textsuperscript{st} semester (61.8%), 4 participants in their 2\textsuperscript{nd} semester (5.9%), 9 participants in their 3\textsuperscript{rd} semester (13.2%), 2 participants in their 4\textsuperscript{th} semester (2.9%), and 11 participants who did not take the survey (16.2%). The distribution of participants according to age category and enrollment included 56 participants who were 18-23 and fulltime (56%), 1 participant who was 24-29 and part-time (1.5%), and 11 participants who did not take the survey (16.2%).
Table 2

*Frequency Statistics of Status, Age Category, and Enrollment of Clicker Group (n=68)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1(^{st}) semester</td>
<td>42</td>
<td>61.8</td>
</tr>
<tr>
<td>2(^{nd}) semester</td>
<td>4</td>
<td>5.9</td>
</tr>
<tr>
<td>3(^{rd}) semester</td>
<td>9</td>
<td>13.2</td>
</tr>
<tr>
<td>4(^{th}) semester</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>16.2</td>
</tr>
<tr>
<td><strong>Age Category</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-23</td>
<td>56</td>
<td>82.4</td>
</tr>
<tr>
<td>24-29</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>30-39</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>16.2</td>
</tr>
<tr>
<td><strong>Enrollment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fulltime</td>
<td>56</td>
<td>82.4</td>
</tr>
<tr>
<td>Part-time</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Dual enrolled</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Only this class</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>16.2</td>
</tr>
</tbody>
</table>
To determine whether significant differences existed between the clicker and non-clicker groups a t-test was conducted for each pretest given. This was conducted to examine equivalency between groups prior to instruction and use of the clicker. Table 3 represents the pretest means and significance values for the t-test calculated for each group. Three of the four t-tests resulted in non-significant values indicating no pre-existing differences between the clicker and non-clicker group, except for Unit 4, in which the non-clicker group (control) scored significantly lower than the clicker group (experimental).

Table 3

*T-test for equivalency between groups*

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest Mean</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clicker</td>
<td>42.94</td>
<td>P=.815</td>
</tr>
<tr>
<td>Non-Clicker</td>
<td>43.75</td>
<td></td>
</tr>
<tr>
<td>Pretest 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clicker</td>
<td>38.31</td>
<td>P=.112</td>
</tr>
<tr>
<td>Non-Clicker</td>
<td>32.55</td>
<td></td>
</tr>
<tr>
<td>Pretest 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clicker</td>
<td>40.48</td>
<td>P=.227</td>
</tr>
<tr>
<td>Non-Clicker</td>
<td>35.71</td>
<td></td>
</tr>
<tr>
<td>Pretest 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clicker</td>
<td>44.44</td>
<td>P=.009*</td>
</tr>
<tr>
<td>Non-Clicker</td>
<td>35.00</td>
<td></td>
</tr>
</tbody>
</table>

*indicates a significant difference
Table 4

*Mean Pretest, Mean Posttest and Gain Score per Unit by Group*

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Gain Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clicker</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest 1</td>
<td>42.94</td>
<td>18.29</td>
<td>10.0</td>
<td>90.0</td>
<td>16.9</td>
</tr>
<tr>
<td>Posttest 1</td>
<td>59.84</td>
<td>21.42</td>
<td>10.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Pretest 2</td>
<td>38.31</td>
<td>19.73</td>
<td>0</td>
<td>90.0</td>
<td>10.02</td>
</tr>
<tr>
<td>Posttest 2</td>
<td>48.33</td>
<td>21.33</td>
<td>0</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>Pretest 3</td>
<td>40.48</td>
<td>21.28</td>
<td>0</td>
<td>80.0</td>
<td>18.96</td>
</tr>
<tr>
<td>Posttest 3</td>
<td>59.44</td>
<td>21.23</td>
<td>10.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Pretest 4</td>
<td>44.44</td>
<td>18.21</td>
<td>10.0</td>
<td>80.0</td>
<td>23.19</td>
</tr>
<tr>
<td>Posttest 4</td>
<td>67.63</td>
<td>20.79</td>
<td>20.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td><strong>Non-Clicker</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest 1</td>
<td>43.75</td>
<td>18.29</td>
<td>10.0</td>
<td>90.0</td>
<td>14.73</td>
</tr>
<tr>
<td>Posttest 1</td>
<td>58.48</td>
<td>18.13</td>
<td>20.0</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>Pretest 2</td>
<td>32.55</td>
<td>17.25</td>
<td>10.0</td>
<td>80.0</td>
<td>13.88</td>
</tr>
<tr>
<td>Posttest 2</td>
<td>46.43</td>
<td>18.32</td>
<td>20.0</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>Pretest 3</td>
<td>35.71</td>
<td>16.99</td>
<td>0</td>
<td>60.0</td>
<td>16.62</td>
</tr>
<tr>
<td>Posttest 3</td>
<td>52.33</td>
<td>18.75</td>
<td>10.0</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>Pretest 4</td>
<td>35.00</td>
<td>18.11</td>
<td>0</td>
<td>80.0</td>
<td>25.95</td>
</tr>
<tr>
<td>Posttest 4</td>
<td>60.95</td>
<td>17.36</td>
<td>20.0</td>
<td>90.0</td>
<td></td>
</tr>
</tbody>
</table>

*minimum= 0 and maximum= 100
Next, Table 4 depicts pretest and posttest mean scores that were compared between groups for each unit. With the minimum = 0 and maximum= 100, the results indicated that for each unit and for both groups the posttest mean score was higher than the pretest mean score. Particularly, the clicker group (experimental) had higher posttest mean scores, for each unit, than the non-clicker group (control). Positive gain scores were shown in both groups when comparing the pretest and posttest. Although, it is worth mentioning that the clicker group gain score was higher on Unit 1 and Unit 3 and the non-clicker group gain score was higher on Unit 2 and Unit 4.

Version 7.3 of the VARK online questionnaire was administered and scores were calculated. Each student received a printout with their learning preference and their sub-scores. The questionnaire consisted of 16 questions which encompassed 4 options for each question, that being either visual, aural, read/write, or kinesthetic learning preference. The questionnaire allowed for multiple answers for each question. Because each of the four modes (V, A, R and K) could have been selected 16 times, there were 64 options spread across the questionnaire with the minimum= 0 and maximum = 16 for each mode. The preference that received the highest total was considered the preferred learning preference. If, in the calculation, there were preferences which were close or equal in score, the student was said to be multimodal. Table 5 represents the mean and standard deviation values for each group, clicker and non-clicker, across all four categories.

When looking at the means for each category, they are close for clicker and non-clicker groups, except kinesthetic scores. The mean score in the clicker group was highest for kinesthetic learning (7.39) and lowest for visual learning (4.30). The mean
score in the non-clicker group was highest for kinesthetic learning (8.67) and lowest for read/write learning (5.05). The predominant learning style for the clicker and non-clicker group was kinesthetic learning.

Table 5

Mean and Standard Deviation Scores of Learning Preference per each Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clicker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual</td>
<td>4.30</td>
<td>2.46</td>
<td>1.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Aural</td>
<td>6.42</td>
<td>2.88</td>
<td>1.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Read/Write</td>
<td>4.80</td>
<td>2.90</td>
<td>0</td>
<td>15.0</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>7.39</td>
<td>2.99</td>
<td>3.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Non-Clicker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual</td>
<td>5.86</td>
<td>3.52</td>
<td>0</td>
<td>13.0</td>
</tr>
<tr>
<td>Aural</td>
<td>6.69</td>
<td>3.11</td>
<td>2.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Read/Write</td>
<td>5.05</td>
<td>3.83</td>
<td>0</td>
<td>13.0</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>8.67</td>
<td>2.94</td>
<td>2.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

*minimum= 0 and maximum= 16

Table 6 depicts the cross tabulation results of learning style preferences based on clicker and non-clicker groups in count and percentages. The table clearly presented the multimodal preference was the most preferred learning style preference for both groups, collectively 56.6%. The non-clicker group resulted in multimodal (57.1%) being the highest learning preference with read/write and visual (4.8%) tying for the lowest
The clicker group resulted in multimodal (56.33%) being the highest learning preference with visual (0%) being the lowest. This is of particular interest being that all college courses taught, traditional or online, are largely visual in nature. Another point noted was the kinesthetic preference was not primarily upheld as the preferred learning preference.

Table 6

Cross-Tabulation Learning Preference Classification of Clicker and Non-Clicker Group

<table>
<thead>
<tr>
<th>Learning Preference</th>
<th>group</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-clicker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aural</td>
<td>Count</td>
<td>3</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>7.1%</td>
<td>17.2%</td>
<td>13.2%</td>
</tr>
<tr>
<td>kinesthetic</td>
<td>Count</td>
<td>11</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>26.2%</td>
<td>25.0%</td>
<td>25.5%</td>
</tr>
<tr>
<td>read</td>
<td>Count</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>4.8%</td>
<td>1.6%</td>
<td>2.8%</td>
</tr>
<tr>
<td>visual</td>
<td>Count</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>4.8%</td>
<td>0.0%</td>
<td>1.9%</td>
</tr>
<tr>
<td>multi</td>
<td>Count</td>
<td>24</td>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>57.1%</td>
<td>56.3%</td>
<td>56.6%</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>42</td>
<td>64</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The Clicker Use Survey was used to calculate mean and standard deviations. With minimum = 0 and maximum = 5, Table 7 reveals the results showing the means of all questions were about the same. Questions 3, 4, 13, 14, 15, and 17 were subjected to
reverse coding. The survey questions used to examine whether clickers were beneficial to student learning were questions 2, 5, 7, 8, 9, 10, 11, 12, 16 and 18. Seven of the ten questions resulted in mean scores which translated to agreeing or strongly agreeing. The remaining three questions depicted means scores translated to undecided or agree. Lastly, 9 of the 18 questions had a standard deviation above 1 indicating a greater variance.

Table 7

*Mean and Standard Deviation for Clicker Survey*

<table>
<thead>
<tr>
<th>Questions</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1- Class time passes more quickly when we use the clickers.</td>
<td>4.32</td>
<td>.85</td>
</tr>
<tr>
<td>Q2- When we use the clickers my participation increases in other ways too.</td>
<td>4.42</td>
<td>.71</td>
</tr>
<tr>
<td>Q3- I found the use of clickers to be distracting and unhelpful.</td>
<td>4.39</td>
<td>.77</td>
</tr>
<tr>
<td>Q4- I feel uncomfortable sharing my responses via the clickers.</td>
<td>4.35</td>
<td>1.06</td>
</tr>
<tr>
<td>Q5- Learning with clickers improves my understanding of the course content.</td>
<td>4.07</td>
<td>.90</td>
</tr>
<tr>
<td>Q6- Learning with the clickers gives me confidence to ask more questions.</td>
<td>3.56</td>
<td>1.23</td>
</tr>
<tr>
<td>Q7- Using the clickers encourages me to spend more time preparing for class.</td>
<td>3.30</td>
<td>1.11</td>
</tr>
<tr>
<td>Q8- Using clickers encourages me to attend more classes.</td>
<td>3.67</td>
<td>1.11</td>
</tr>
</tbody>
</table>
Table 7 (continued).

<table>
<thead>
<tr>
<th>Questions</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9- Using the clickers promotes more focused discussion during class.</td>
<td>4.30</td>
<td>.76</td>
</tr>
<tr>
<td>Q10- I would like to use the clickers in other courses.</td>
<td>4.44</td>
<td>.85</td>
</tr>
<tr>
<td>Q11- The graphs provided by the clicker system are useful.</td>
<td>4.21</td>
<td>1.05</td>
</tr>
<tr>
<td>Q12- I benefit by seeing how other students respond to a question.</td>
<td>3.93</td>
<td>1.13</td>
</tr>
<tr>
<td>Q13- Using the clickers in class is too time consuming.</td>
<td>4.26</td>
<td>.79</td>
</tr>
<tr>
<td>Q14- I would do better in this class without the clickers.</td>
<td>4.19</td>
<td>.93</td>
</tr>
<tr>
<td>Q15- I had difficulties getting my clicker to work in class.</td>
<td>4.44</td>
<td>.80</td>
</tr>
<tr>
<td>Q16- I would have liked to use the clickers more often in class.</td>
<td>4.09</td>
<td>1.21</td>
</tr>
<tr>
<td>Q17- At first, learning with the clickers was enjoyable but later I was board.</td>
<td>4.12</td>
<td>1.00</td>
</tr>
<tr>
<td>Q18- Using the clickers helped to better prepare me for quizzes and exams.</td>
<td>4.16</td>
<td>1.03</td>
</tr>
</tbody>
</table>

*minimum= 0 and maximum= 5

Results of Research Questions and Hypotheses

Results of Research Question

Research Question One: Are there statistically significant differences in pretest and posttest scores between students, when controlling for learning style, which are and are not subjected to implementation of clicker technology in a non-major biology course?
A repeated-measures multivariate analysis of variance (MANOVA) was utilized to determine if significant differences existed between the effects pretest/posttest (time), unit (1, 2, 3, & 4), and clicker/non-clicker (group) when using learning styles preference as the covariate. The results revealed \( \text{time} = F (1, 65) = 4.10, p = .047, \text{unit} = F (3, 65) = 4.55, p = .006, \text{group} = F (1, 65) = 2.957, p = .090. \) No significant interactions (i.e. \( p > .05 \)) with the learning styles preference covariate were present, except for unit which was not one of the selected interaction. This suggests that the clickers did not have any effect on the pretest/posttest of either group, control or experimental. However, there were significant increases in posttest means compared to pretest means. Particularly, the clicker group (experimental) had higher posttest mean scores, for each unit, than the non-clicker group (control). The clicker group gain score was higher on Unit 1 and Unit 3, while the non-clicker group gain score was higher on Unit 2 and Unit 4.

**Results of Research Question Two**

Research Question Two: Are there statistically significant differences in retention rates between non-major biology courses that do and do not implement clicker technology?

Cross tabulation results of students completing the course and group assignment is depicted in Table 8. In the clicker course, 86.8% of students completed the course, compared to 84% of students in the non-clicker course. Likewise, in the clicker classes, 13.2% of students failed to complete the course, compared to 16% of students in the non-clicker courses.
Table 8

Cross Tabulation of Attrition within Clicker and Non-Clicker Groups

<table>
<thead>
<tr>
<th>Completion Status</th>
<th>Group</th>
<th>Non-clicker</th>
<th>Clicker</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed</td>
<td>Count</td>
<td>42</td>
<td>59</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>84%</td>
<td>86.8%</td>
<td>85.6%</td>
</tr>
<tr>
<td>Did not complete</td>
<td>Count</td>
<td>8</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>16%</td>
<td>13.2%</td>
<td>14.4%</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>50</td>
<td>68</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Although the attrition rate for the clicker courses was lower, the Pearson Chi-square analysis revealed that this difference was not significant, \( x^2 (N=118, df=1) = .019, p= .891 \). The cross tabulations and Chi-square both indicate that \( H_02 \) was not supported.

Results of Research Question Three

Research Question Three: Will students of different learning styles differ in their perceptions of implementing clickers, in a non-major biology class, as being beneficial to their learning process?

In order to determine if all students, including all learning style preferences, perceived clickers as being beneficial to their learning a one-way ANOVA was conducted. Results from the ANOVA revealed for the between groups, perception scores and learning styles, they were not significant (i.e. \( p > .05 \)); \( F (3, 52) = .296, p= .828 \).
This suggests that student’s perceptions of clickers do not differ by learning style preferences.

Summary

By utilizing descriptive statistics, frequencies, Chi-Square, ANOVAs, and MANOVAs the research questions were answered. This study investigated if implementing clicker technology would affect student achievement, when administered the same pretest and posttest, and student retention in non-major biology classes who were and were not subjected to the technology. The study also sought to determine if students with different learning style preferences would perceive using clickers as beneficial to their learning. The results of these research questions revealed that students who were subjected to clicker technology did not have statistically higher test scores than those who are not subjected to clickers. It also revealed that clickers did not statistically helped retain students to complete the course. Lastly, the results indicated that there was no significant statistical difference in clicker perception scores between the different learning style preferences. Research hypothesis one, two, and three were rejected.

Chapter V presents the conclusions based from the findings gathered from this study. The content also discusses the implications of these findings concerning clicker use in college classrooms and how instructors should or should not use them for engaging students in learning material. Limitations and suggestions for further research are offered to help other researchers expand upon this study.
CHAPTER V
DISCUSSION

Summary of the Study

The foundation of this study was to investigate if implementing clicker technology had any effect on student achievement and student retention in non-major biology courses for students who did and did not receive the technology while controlling for learning style preferences. The study also examined if students with different learning styles would differ in considering clickers as beneficial to their learning. A quantitative research design was utilized to measure the research variables. Four sections of a non-major biology course, in a southern community college, were randomly assigned to either a control (n=2) or experimental group (n=2). Complete randomization was not feasible for this study because students self-selected the course-time and instructor.

Numerous statistical analyses were utilized to test the research variables, including descriptive statistics and frequencies. A repeated measures MANOVA was conducted to measure student achievement based on comparing the pretest and posttest scores between the experimental (clicker) and control (non-clicker groups). Independent t-test were conducted to check for equivalency between groups on unit pretest scores. Cross tabulations and Chi-square were utilized to measure student retention between groups. The VARK online questionnaire was administered to determine students learning style preference, while the Clicker Use Survey was used to measure students perception on clicker usage. Lastly, the one-way ANOVA was utilized to determine if all students, which included all learning styles preferences, perceived clickers as beneficial to their learning.
Analysis of Research Questions and Hypotheses

Research Question One

In regards to the first research question, there was not a statistically significant difference in pretest and posttest scores in non-major biology courses where one group was taught using clickers and the other was taught using traditional lecture format. However, statistical analyses indicated that for both groups, non-clicker (control) and clicker (experimental), the posttest scores were higher for all four units. Three of the four t-test conducted to measure for equivalency between groups for all unit pretest resulted in non-significant values indicating no pre-existing differences, except for Unit 4, in which the non-clicker control group scored significantly lower than the clicker experimental group. Students were required to enroll in a corresponding non-majors biology lab. The lab course was taught separately from the lecture course and by different instructors. This could explain the difference encountered with Unit 4. Some students might have been exposed to some of the course content information before other students, simply by attending an earlier lab. Although posttest mean scores were higher in both groups, the clicker experimental group did have higher mean scores than the non-clicker control group.

Equally important to note was the posttest mean scores between both groups controlling for learning styles. A repeated-measures MANOVA was conducted to see if any differences existed between the effects pretest/posttest (time), unit (1, 2, 3, &4), and clicker/non-clicker groups while using learning style preferences as the covariate. There were increases in posttest means compared to pretest means for both groups, but this was not significant. The clicker group did achieve a higher gain score on Unit 1 and Unit 3
and the non-clicker group gain score was higher on Unit 2 and Unit 4. This endorses the results of Paschal (2002) who also obtained positive gains when using clickers in science courses, but the gain was not measured as significant.

However, the results of the MANOVA indicated no significant interactions between the research variables and the covariate. This suggests that clickers did not have any effect, negative or positive, on the pretest/posttest of the clicker experimental group. Also, this proposes that the use of clickers did not benefit one learning style preference over another. This does not support the research that claims kinesthetic learners perform better if they are able to manipulate tools and move around.

In summary, there was no statistical difference when comparing the results of student achievement from non-major biology courses who did and did not implement clicker technology when controlling for learning styles. This study’s results addressing student achievement were supported by Caldwell (2007), Herreid (2006), Kenwright (2009), Martyn (2007) and many others who also found that clickers did not improve the achievement of their students. The research hypotheses was not supported in this study.

**Research Question Two**

Pertaining to the second research question, there was not a statistically significant difference in retention rates between non-major biology courses that did and did not implement clicker technology. The strategy of implementing clicker technology to help increase attendance has quickly gained speed. Research focusing on whether clickers increase course completion (retention) is insignificant. Numerous studies agreed that attendance did improve when clicker usage was linked to the student’s course grade (Cue, 1998; Greer & Heaney, 2004; Jackson & Trees, 2003). However, they differed on what
percentage attendance should count toward the grade. Positive results in attendance were noticed when clicker participation contributed to as little as 5% of the student’s average (Caldwell, 2007). This study employed clicker participation as 10% of the student’s total average, for the experimental group. The control group received 10% of their average from class participation. The results from cross tabulations conducted indicated less students in the clicker experimental group dropped the course than in the non-clicker control group. Although the attrition rate for the clicker courses were lower, the Chi-square analysis revealed this difference was not significant.

These findings were consistent with studies by Caldwell (2007), King and Robinson (2009), and Morling, McAuliffe, Cohen, and Dilorenzo (2008) who observed that clicker usage did not affect attendance, positively or negatively, over the entire semester. The current study did however, refute the results of Trenholm and Dunnet (2007) who found that non-clicker classes had greater attendance rates than the classes who did use the clickers. This hypothesis was not supported by the results of the study.

Research Question Three

Regarding the third research question, there was not a difference between students of different learning styles in their perceptions of implementing clickers as being beneficial to their learning process, in a non-major biology class. In this study the learning style preference of each participant was classified using the online VARK Questionnaire. The questionnaire labeled participants either as visual, aural, read/write, kinesthetic, or multi-modal, which means showing equal strength in more than one mode. The Clicker Use Survey assessed the perceptions of students toward the use of the clicker technology. Results from a one-way ANOVA revealed that between groups, perception
scores and learning style preference were not significant. This suggests that student’s perceptions of clickers do not differ statistically by learning styles.

These results mirror research conducted by Sprague and Dahl (2009) who concluded that attitudes students have toward clicker usage did not depend on their learning style. Young, Klemz, and Murphy (2003) suggests this is because students view technology as simply a tool in providing instruction. Although, majority of the students perceived clickers as being beneficial, there was no significant difference found within learning style. Thus, the results did not support the hypotheses.

Implications for Practice

Although statistically significant results in student achievement and student retention have not been found in this research, the study does lend itself to several implications for practice when implementing clicker technology. This study supports research that indicates clicker technology does not seem to have an effect, positive nor negative, on student achievement when compared to classes not implementing the technology. The implications of this information could be beneficial for administration when weighing the financial burden, for either the student or institution, against the purchase and implementation of clicker technology. Also, institutions should stay abreast and be open-minded to developing options, such as mobile/Wi-Fi polling devices, which are cheaper and already owned by most students. This could defer institutional cost and while providing more opportunities for research data to be collected.

Even though community college funding is shifting toward performance-based results, there are still many states that rely on student retention to fund their institutions. The lack of statistically significant results of student retention, which differs when
compared to outcomes of other studies, proposes that the effects of clicker technology is still undetermined. It could be advantageous for colleges to implement clicker technology to increase attainment that ultimately sustains some institutions financially. The results from the Clicker Use Survey reveal that students do like using clickers and would like to use them in other classes. The results also indicate when students use clickers their participation increases in other ways too. With that said, this technology is engaging to students and allow them to be interactive in the learning process. A literature review conducted by Caldwell (2007) found that when students were more engaged in an active environment the retention rates were higher.

Lastly, the study adds to the limited research on whether technology affects all students of every learning style equally. If tailored instruction can improve achievement and achievement can improve retention, then ultimately retention secures financial stability. The implications of acknowledging that students learn differently affect every level, administration, faculty, and students. Prudent for all involved and at every level is to consider how best to combine interactive technology with the appropriate pedagogy, or mix thereof, to facilitate learning across every learning style.

Limitations of the Study

Although this study is an important first step towards understanding the effect clicker technology has on student achievement and student retention, several limitations of the study exist.

1. This study was limited to students who registered for non-major biology course in a southern community college in the fall of 2014. Complete randomization was not feasible because students self-selected course time and
instructor, although the control and experimental groups were chosen at random.

2. This study was limited to investigating the implementation of clickers as an engaging technological tool with its regard to student achievement and student retention.

3. This study was limited to investigating only clicker technology. Additional engaging technologies were not evaluated during this study.

4. This study was limited to measure student achievement to post-test scores. Control and experimental groups were proven equivalent based on the pretest before each unit, but other factors like work, extra-curricular activities, and family responsibilities were not measured. These variables could have impacted either group.

Recommendations for Future Research

Even with the lack of significant results in this study, additional studies employing clicker technology in community college courses are needed. While the results of this study do contradict that of others, they can lead to more focused studies for future examination in this area.

First recommendation is to investigate the type of pedagogy, combined with clicker usage, works best when evaluating achievement of students with different learning styles. Also, such studies should assess within each learning style whether gender, ethnic groups, or other descriptive variables have any effect.

Second recommendation is for researchers to consider the results of a learning style questionnaire and modify instruction based on the preferences of each class, still
keeping a quantitative, quasi-experimental research design. This would provide an insight into the relationship that tailored instruction and clicker technology might have with regards to learning styles.

Third recommendation is to evaluate student’s perception on clicker usage more than once during the semester. Because the survey was given at the end of the semester the students could have already established what their average would be and this may skew results. By measuring student’s perceptions more than once you would be able to compare the results.

Lastly, a recommendation is to conduct this study as a longitudinal study and include non-major and major biology courses. Additionally, introducing mobile technology such as cell phones in addition to clicker technology can offer a point of comparison. Do the use of clickers/cell phones affect retention rates differently in major and non-major biology courses? Taking into account descriptive variables for comparison, such as, time of day class is offered, length of class time and mode of instruction (traditional, hybrid, and accelerated terms) should be considered when performing such studies on clicker technologies.
APPENDIX A

PERMISSION TO USE CONCEPTTEST GRAPHIC AND METHOD

From: Eric Mazur [mailto:mazur@seas.harvard.edu]
Sent: Tuesday, June 17, 2014 3:48 PM
To: Thames, Tasha M.
Subject: Re: Permission to Use Graphic

Dear Tasha,

By all means! Happy to hear that my work is useful to you and more than happy to have you include/manipulate the graphic below.
Best wishes,
Eric

Eric Mazur
Harvard University
Area Dean of Applied Physics
Balkanski Professor of Physics and of Applied Physics

On Jun 17, 2014, at 3:02 PM, Thames, Tasha M. <tmthames@iccms.edu> wrote:
Greetings Dr. Mazur,

My name is Tasha Thames, and I am pursuing a Ph.D. in Science Education from the University of Southern Mississippi through the Center of Science and Mathematics Education. I currently teach Principles of Biology and Anatomy and Physiology at Itawamba Community College in Fulton, Mississippi.

Your work is of the utmost interest to me both professionally and academically. Currently, I am gathering and studying your research on motivation of students. I find your work fascinating and extremely pertinent to my area of interest. I am interested in manipulating the ConceptTest Process and graphic displayed below in my research. The purpose of my research is investigating student retention and student achievement of non-major biology students who are subjected to implementation of clicker technology. After much review, I find myself being most intrigued by your research findings when incorporating peer instruction with clicker technology.

I believe that combining clickers with peer instruction is best suited for the purposes of my dissertation. I am asking for written permission to use this graphic in my dissertation. I am required by my Institutional Review Board to include written permission in order to include it. Would it be possible for you to provide me with this?

Thank you for your time and consideration,
Tasha Thames
APPENDIX B

GRADUATION IT MATTERS 101 CLICKER QUESTIONS

1. Graduation It MATTERS 101

2. There is no minimal GPA a student must have to graduate.
   A. True
   B. False

3. Which of the following prefixes do not count toward an AA degree?
   A. MAT, ENG, MFL
   B. PHI, SFT, PHY
   C. INT, MAT, TAM
   D. GEO, SOC, BIO
   E. CHE, HIS, ECO

4. A student is not allowed to participate in graduation ceremonies without completing all course work.
   A. True
   B. False

5. How many extra curricular hours can go toward graduation?
   A. 5
   B. 3
   C. 6
   D. 0

6. What are the credit hour requirements for the categories of Humanities and Fine Arts?
   A. Humanities and Fine Arts must equal 6 hours total
   B. Humanities = 5
   Fine Arts = 6
   C. Humanities = 6
   Fine Arts = 3
   D. Humanities and Fine Arts must equal 9 hours total
1 Mande Miller- Advising Director
2 Graduation It MATTERS
101
2 Which of the following prefixes do not count toward an AA degree?
   A. MAT, ENG, MFL
   B. PHI, SPT, PHY
   C. BOT, MMT, TAH
   D. GEO, SOC, BIO
   E. CHE, HIS, ECO
3 How many extra curricular hours can go toward graduation?
   A. 3
   B. 5
   C. 6
   D. 8
4 There is no minimal GPA a student must have to graduate.
   A. True
   B. False
5 A student is not allowed to participate in graduation ceremonies without completing all course work.
   A. True
   B. False
6 What are the credit hour requirements for the categories of Humanities and Fine Arts?
   A. Humanities and Fine Arts must equal 6 hours total
   B. Humanities = 3
      Fine Arts = 6
   C. Humanities = 6
      Fine Arts = 3
   D. Humanities and Fine Arts must equal 9 hours total
APPENDIX C

THE VARK QUESTIONNAIRE

Questionnaire version 7.3                                Student Code: _____________________

Choose the answer which best explains your preference and check the boxes(s) next to it. Please check more than one if a single answer does not match your perception. Leave blank any question that does not apply.

1. I like websites that have:
   - Audio channels where I can hear music, radio programs or interviews.
   - Things I can click on, shift or try.
   - Interesting written descriptions, lists and explanations.
   - Interesting design and visual features.

2. A group of tourists wants to learn about the parks or wildlife reserves in your area. You would:
   - Give them a book or pamphlets about the parks or wildlife reserves.
   - Talk about, or arrange a talk for them about parks or wildlife reserves.
   - Show them maps and internet pictures.
   - Take them to a park or wildlife reserve and walk with them.

3. You are helping someone who wants to go to your airport, the center of town or railway station. You would:
   - Tell her the directions.
   - Go with her.
   - Write down the directions.
   - Draw, or show her a map, or give her a map.

4. A website has a video showing how to make a special graph. There is a person speaking, some lists and words describing what to do and some diagrams. You would learn most from:
Listening.
Seeing the diagrams.
Watching the actions.
Reading the words.

5. Do you prefer a teacher or a presenter who uses:

☐ Handouts, books, or readings.
☐ Question and answer, talk, group discussion, or guest speakers.
☐ Demonstrations, models or practical sessions.
☐ Diagrams, charts or graphs.

6. You are going to choose food at a restaurant or cafe. You would:

☐ Choose something that you have had there before.
☐ Listen to the waiter or ask friends to recommend choices.
☐ Choose from the descriptions in the menu.
☐ Look at what others are eating or look at pictures of each dish.

7. You have finished a competition or test and would like some feedback. You would like to have feedback:

☐ From somebody who talks it through with you.
☐ Using a written description of your results.
☐ Using examples from what you have done.
☐ Using graphs showing what you had achieved.

8. You are planning a vacation for a group. You want some feedback from them about the plan. You would:

☐ Phone, text or email them.
☐ Describe some of the highlights they will experience.
☐ Give them a copy of the printed itinerary.
☐ Use a map to show them the places.
9. Remember a time when you learned how to do something new. Avoid choosing a physical skill, e.g. - riding a bike. You learned best by:

- Watching a demonstration.
- Written instructions – e.g. a manual or book.
- Listening to somebody explaining it and asking questions.
- Diagrams, maps, and charts - visual clues.

10. Other than price, what would most influence your decision to buy a new non-fiction book?

- Quickly reading parts of it.
- It has real-life stories, experiences and examples.
- A friend talks about it and recommends it.
- The way it looks is appealing.

11. You are going to cook something as a special treat. You would:

- Cook something you know without the need for instructions.
- Look on the Internet or in some cookbooks for ideas from the pictures.
- Use a good recipe.
- Ask friends for suggestions.

12. You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have:

- Many examples of good and poor photos and how to improve them.
- Diagrams showing the camera and what each part does.
- Clear written instructions with lists and bullet points about what to do.
- A chance to ask questions and talk about the camera and its features.

13. You have to make an important speech at a conference or special occasion. You would:
Gather many examples and stories to make the talk real and practical.
Write a few key words and practice saying your speech over and over.
Write out your speech and learn from reading it over several times.
Make diagrams or get graphs to help explain things.

14. You want to learn a new program, skill or game on a computer. You would:

- Use the controls or keyboard.
- Talk with people who know about the program.
- Follow the diagrams in the book that came with it.
- Read the written instructions that came with the program.

15. You are about to purchase a digital camera or mobile phone. Other than price, what would most influence your decision?

- It is a modern design and looks good.
- Trying or testing it
- Reading the details or checking its features online.
- The salesperson telling me about its features.

16. You have a problem with your heart. You would prefer that the doctor:

- Described what was wrong.
- Used a plastic model to show what was wrong.
- Gave you something to read to explain what was wrong.
- Showed you a diagram of what was wrong.

APPENDIX D

PERMISSION TO USE VARK SURVEY

Thames, Tasha M.

From: Fleming Neil <flemingn@ihug.co.nz>
Sent: Monday, July 07, 2014 4:22 PM
To: Thames, Tasha M.
Subject: Using VARK

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APPENDIX E
CLICKER USE SURVEY

Student Code: _____________________

Check One in Each Category:

Gender: _____ Male   _____ Female
Status: _____ 1st semester   _____ 2nd semester   _____ 3rd semester   _____ 4th semester
Age Category: _____ 18-23   _____ 24-29   _____ 30-39   _____ 40 and over
Enrollment: _____ Full Time   _____ Part Time   _____ Dual Enrolled   _____ Only this Class

Please respond to each question by circling number from 1 to 5.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Class time passes more quickly when we use the clickers.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>When we use the clickers my participation increases in other ways too.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>I found the use of clickers to be distracting and unhelpful.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>I feel uncomfortable sharing my responses via the clickers.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>Learning with clickers improves my understanding of the course content.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>Learning with the clickers gives me confidence to ask more questions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>Using the clickers encourages me to spend more time preparing for class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>Using clickers encourages me to attend more classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>Using the clickers promotes more focused discussion during class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>I would like to use the clickers in other courses.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>The graphs provided by the clicker system are useful.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>I benefit by seeing how other students respond to a question.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>Using the clickers in class is too time consuming.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>I would do better in this class without the clickers.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15.</td>
<td>I had difficulties getting my clicker to work in class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16.</td>
<td>I would have liked to use the clickers more often in class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>At first, learning with the clickers was enjoyable but later I was bored.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18.</td>
<td>Using the clickers helped to better prepare me for quizzes and exams.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX F

PERMISSION TO USE CLICKER SURVEY

Thames, Tasha M.

From: Tim Pelton <pelton@uvic.ca>
Sent: Thursday, April 24, 2014 7:15 PM
To: Mary Sanseverino
Cc: Thames, Tasha M.; Leslee Francis Pelton
Subject: Re: Permissions Request

Yes, permission granted from Tim Pelton and Leslee Francis Pelton too.

Tim

Tim Pelton
Associate Professor
Faculty of Education
University of Victoria
Cell: 778-977-6276
Office: 250-721-7003

On Apr 24, 2014, at 4:15 PM, "Mary Sanseverino" <msanseve@uvic.ca> wrote:

Hello Ms. Thames
Does email count as written permission?
Regards
Mary

Mary Sanseverino

Sent from my iPad

On 2014-04-24, at 3:16 PM, "Thames, Tasha M." <tmthames@icms.edu> wrote:

Greetings Dr.Tim Pelton, Dr. Leslea Pelton and Ms. Sanseverino,

My name is Tasha Thames. Currently I teach at Itawamba Community College in Fulton, MS. I am also a Ph.D. candidate in the Science Education program at the University of Southern Mississippi in Hattiesburg, MS.

Your article, “Clicker Lessons: Assessing and Addressing Student Responses to Audience Response Systems”, published in Collected Essays on Learning and Teaching was thoroughly enjoyable. Your collective work is of the utmost interest both professionally and academically. I am in the process of gathering and studying research on the effectiveness of clickers. After disseminating numerous surveys, your survey is best suited for the purpose of my dissertation.

The purpose of my research is investigating retention and student achievement of non-major biology students who are subjected to implementation of clicker
APPENDIX G

PRETEST/POSTTEST FOR FOUR UNITS

Unit One Pre/Post Test

1. Which of the following subatomic particles will be found within the nucleus of the atom?
   A. protons & neutrons
   B. protons & electrons
   C. electrons & neutrons
   D. only neutrons
   E. only protons

2. Which of the following sequences correctly lists the bonds in order of strongest to weakest?
   A. single covalent - double covalent - ionic - hydrogen
   B. ionic - double covalent - single covalent - hydrogen
   C. double covalent - single covalent - ionic - hydrogen
   D. hydrogen - double covalent - single covalent - ionic
   E. double covalent - single covalent - hydrogen - ionic

3. If an element has an atomic number of 12, how many electrons are in its outermost shell?
   A. 1
   B. 10
   C. 8
   D. 2
   E. 12

4. If neutral atoms become positive ions, they
   A. gain electrons.
   B. lose electrons.
   C. gain protons.
   D. lose protons.
   E. do not change.

5. Which of the following molecules is NOT a compound?
   A. H₂O
   B. HCl
   C. H₂
   D. C₆H₁₂O₆
   E. NaOH
6. The pH of blood is slightly basic. Which of the following would therefore be an expected pH for blood?
   A. 6.4
   B. 7.4
   C. 4.6
   D. 4.7
   E. 13.8

7. The final shape of a protein is very important to its function. When proteins undergo an irreversible change in shape called ________________ they ________________ perform their usual functions.
   A. naturation/can
   B. naturation/cannot
   C. denaturation/can
   D. denaturation/cannot
   E. dehydration reaction/cannot

8. A piece of petrified wood was once part of a living organism, but its tissues have been replaced by minerals and it no longer exhibits most properties of life, except for
   A. organization.
   B. homeostasis.
   C. growth and reproduction.
   D. response to stimuli.
   E. metabolism.

9. As the human population size increases,
   A. ecosystems remain unaffected.
   B. fewer fossil fuels are burned and carbon dioxide levels remain constant.
   C. it becomes evident that preserving the biosphere has no benefit to humans.
   D. fewer ecosystems are destroyed, resulting in an abundance of biodiversity.
   E. biodiversity is adversely affected as humans have destructive effects on ecosystems.

10. You are conducting an experiment to determine what concentration of disinfectant is most effective in killing bacteria. In this example, the concentration of disinfectant would represent the
    A. control.
    B. experimental variable.
    C. response variable.
    D. data.
    E. hypothesis.
Unit Two Pre/Post Test

1. Circulating red blood cells in your body do not contain a nucleus and other organelles. Are these cells living?
   A. Yes, because they are actively metabolizing and once contained organelles.
   B. Yes, because they are capable of moving throughout the body in the circulation.
   C. No, because they do not contain a nucleus, they cannot be living.
   D. No, because red blood cells do not actively metabolize.
   E. No, because they are now only part of a once living cell.

2. Antibiotics should be selectively toxic, that is, they should attack the infecting bacteria without harming you. Which of the following would be a good target for an antibiotic so it doesn't attack your cells?
   A. plasma membrane
   B. DNA
   C. ribosomes
   D. cytoplasm
   E. endoplasmic reticulum

3. Within eukaryotic cells, the ____ is surrounded by a double membrane and carries the coding that determines protein synthesis.
   A. smooth endoplasmic reticulum
   B. chloroplast
   C. nucleolus
   D. nucleus
   E. rough endoplasmic reticulum

4. What evidence suggests that proteins are synthesized and modified in the rough ER as opposed to the smooth ER?
   A. ribosomes are associated with the surface of the rough ER.
   B. ribosomes are associated with the surface of the smooth ER.
   C. proteins can be found in the membrane of the rough ER but not the smooth ER.
   D. the smooth ER functions in the synthesis of phospholipids.
   E. smooth ER is continuous with rough ER.

5. The inside and outside of the plasma membrane are
   A. identical in both the phospholipid bilayer and the embedded proteins.
   B. identical in phospholipid bilayer but have cytoskeletal filaments on the outside and carbohydrate chains of glycolipids and proteins on the inside.
   C. identical in phospholipid bilayer but have cytoskeletal filaments on the inside and carbohydrate chains of glycolipids and proteins on the outside.
   D. different with a phospholipid bilayer on the inside and carbohydrate chains of glycolipids and proteins on the outside.
E. different with a phospholipid bilayer on the outside and carbohydrate chains of glycolipids and proteins on the inside.

6. A student sitting on the back row opened a bottle of foul-smelling perfume and dabbed it on her wrists. One-by-one (beginning from the back of the room) the students began to cough due to the foul smell. This phenomena was due to
   A. osmosis.
   B. molecules moving from an area of low concentration to high concentration.
   C. an allergic reaction.
   D. diffusion.
   E. active transport.

7. Carrier molecules are required for
   A. osmosis.
   B. both osmosis AND diffusion.
   C. facilitated diffusion.
   D. active transport.
   E. both facilitated diffusion AND active transport.

8. Upon examination, a cell is found to have twice as much DNA as the normal diploid state but is no longer in the process of replicating the DNA. All of the DNA is found within a single nucleus. Which stage of the cell cycle is this cell in?
   A. M phase
   B. G2 phase
   C. G1 phase
   D. S phase
   E. cytokinesis

9. Which is NOT a correct association?
   A. cytokinesis-division of the cytoplasm
   B. centromere-point where sister chromatids remain attached
   C. haploid-one of each chromosome
   D. sister chromatids-two identical chromosome strands still attached at the centromere
   E. mitosis-when a cell duplicates and then divides twice to reduce chromosome number by half

10. If a crayfish has 200 total chromosomes in its body cells (not ovaries or testes)
    A. any 100 could have been from its father and any 100 from its mother.
    B. they would consist of 100 pairs with one of each pair from the father, one of each pair from the mother.
    C. as many as none-to-200 came from the father and conversely, from 200-to-none would have come from the mother.
    D. 50 pairs or 100 total would come from the father and 50 pairs from the mother.
    E. all 200 come from the mother in a female crayfish, all 200 from the father in a male crayfish.
Unit Three Pre/Post Test

1. We often say that we need food for energy. In a biological sense, is this correct?
   A. Yes, because the smallest units inside the atoms that make up the food are simply pure energy.
   B. Yes, because the food must move through the digestive system, and motion is kinetic energy.
   C. Yes, because the food we eat has potential energy in its structure and this chemical energy can be converted into mechanical energy.
   D. No, because food consists of matter and cannot be transformed into energy.
   E. No, since all food matter stays matter, and energy remains energy.

2. The various uses of ATP include all of the following except
   A. being a structural component of the cell membrane.
   B. chemical work.
   C. mechanical work.
   D. transport work.
   E. moving substances into a cell.

3. During an enzymatic reaction, what happens to the enzyme?
   A. It becomes the product.
   B. It becomes the substrate.
   C. It is used up.
   D. The enzyme and the substrate form a permanent complex.
   E. The enzyme and the substrate form a temporary complex.

4. Which of the following statements is not true concerning enzymatic activity?
   A. Each enzyme has a preferred pH at which the enzyme reaction rate is highest.
   B. Above a certain temperature, an enzyme will become denatured.
   C. As the temperature increases, most enzymatic reactions will still proceed at the same rate.
   D. Enzymatic reactions proceed quite rapidly.
   E. Enzyme activity increases as substrate concentration increases until the maximum rate is achieved.

5. Cellular respiration involves all of the following except
   A. the breaking down of molecules.
   B. the release of energy.
   C. the synthesis of ATP.
   D. breathing in and out.
   E. the release of carbon dioxide.

6. What is the correct order of phases in cellular respiration?
   A. citric acid cycle, prep reaction, glycolysis, electron transport chain
   B. electron transport chain, glycolysis, prep reaction, citric acid cycle
   C. prep reaction, glycolysis, electron transport chain, citric acid cycle
D. glycolysis, prep reaction, citric acid cycle, electron transport chain
E. glycolysis, citric acid cycle, prep reaction, electron transport chain

7. Which is NOT correct about the preparatory reaction?
A. It connects glycolysis to the citric acid cycle.
B. CO₂ is given off.
C. Pyruvate is converted to a 2-carbon acetyl group.
D. NAD⁺ goes to NADH + H⁺ as acetyl-CoA forms.
E. The reaction occurs once per glucose molecule.

8. Photosynthesis shows higher activity for violet/blue and orange/red and a lower absorption for green/yellow. If we could invent a different photosynthetic pigment that absorbed absolutely all visible wavelengths of light, the leaves would appear which color?
A. white
B. black
C. red
D. green
E. orange

9. The formation of carbohydrate occurs within the
A. stroma.
B. outer chloroplast membrane.
C. inner chloroplast membrane.
D. thylakoid membranes.
E. thylakoid space.

10. Some herbicides inhibit the electron transport chain in the thylakoid membrane. Without the movement of electrons, hydrogen ions would not be pumped from the stroma to the thylakoid space and the hydrogen ion gradient would not be established. How would this affect the Calvin cycle reactions?
A. ATP would not be produced and as a result, the Calvin cycle reactions would not occur.
B. CO₂ would not enter the cell as a result and the Calvin cycle reactions would not occur.
C. RuBP carboxylase would not function properly so CO₂ fixation would not occur.
D. Sunlight could no longer be used by the chloroplast, but this would have no effect on the Calvin cycle reactions because they do not require light.
E. Since the Calvin cycle reactions occur in a different part of the chloroplast, there would be no effect.
Unit Four Pre/Post Test

1. Mendel’s law of segregation implies that the two members of an allele pair
   A. are distributed to separate gametes.
   B. are distributed to the same gamete.
   C. are assorted dependently.
   D. are segregated pairwise.
   E. must always code for the identical trait or feature.

2. Which of the following is NOT true about RNA?
   A. RNA transfers messages from DNA to ribosomes.
   B. RNA contains the sugar ribose.
   C. RNA contains adenine, guanine, uracil, and cytosine.
   D. RNA is single stranded.
   E. RNA forms a helix.

3. In humans, brown eyes (B) is a simple dominant trait over blue eyes (b). A brown-eyed woman whose child is blue-eyed would have the genotype
   A. bb.
   B. Bb.
   C. BB.
   D. BBB.
   E. BbBb.

4. A pheasant breeder starts with two birds in the P generation, one of which is AA and the other is aa. If he takes two of the birds from the F₁ generation and breeds them together, what can he expect in his F₂ offspring?
   A. AA and Aa.
   B. Aa and aa.
   C. AA, Aa, and aa.
   D. AA only.
   E. Aa only.

5. A man with widow’s peak (dominant) who can curl his tongue (dominant) has a child who has a continuous hairline and cannot curl the tongue. What is the genotype of the father?
   A. WWTT
   B. wwtt
   C. WwTt
   D. Wwt
   E. WT

6. Color-blindness is inherited as an X-linked recessive trait. A male who is color-blind marries a heterozygous woman. What percent of their total children will be color-blind?
   A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

7. Generally, it is not possible to determine whether nondisjunction failed to occur in oogenesis or spermatogenesis. However, it is possible to assert that _____ resulted in nondisjunction in ____.
   A. XXY; oogenesis
   B. XYY; spermatogenesis
   C. XXX; oogenesis
   D. XXY; spermatogenesis
   E. XO; oogenesis

8. The trait diagrammed in Figure 24.1 is a(n)
   A. dominant X-linked trait.
   B. recessive X-linked trait.
   C. autosomal recessive trait.
   D. autosomal dominant trait.
   E. dominant Y-linked trait.

9. Which of the following statements about DNA replication is NOT correct?
   A. Unwinding of the DNA molecule occurs as hydrogen bonds break.
   B. Replication occurs as each base is paired with another exactly like it.
   C. The process is known as semi-conservative replication because one old strand is conserved in the new molecule.
   D. The enzyme that catalyzes DNA replication is DNA polymerase.
   E. Complementary base pairs are held together with hydrogen bonds

10. For translation to take place, which of the following would NOT be required to be present?
    A. DNA
    B. mRNA
    C. tRNA amino acid complex
D. rRNA
E. Ribosome
APPENDIX H

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**Request ID/Invoice Number:** TAS44620

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For McGraw-Hill:
Ann Irons
APPENDIX I
USM IRB APPROVAL

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 21, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
- Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 14080401
PROJECT TITLE: Novelty or Knowledge? A Study of Using a Student Response System in Non-Major Biology Courses at a Community College
PROJECT TYPE: New Project
RESEARCHER(S): Tasha Thomas
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: Center for Science and Math Education
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Exempt Review Approval
PERIOD OF APPROVAL: 08/19/2014 to 08/12/2015

Lawrence A. Hosman, Ph.D.
Institutional Review Board
APPENDIX J

ITAWAMBA COMMUNITY COLLEGE IRB

August 15, 2014

Tasha Thames
Biology Instructor
Itawamba Community College
602 West Hill Street
Fulton, MS 38843

Re: IRB Approval
Novelty or Knowledge? A Study of Using a Student Response System in non-major Biology Courses at a Community College

Dear Tasha Thames:

The above referenced project/research topic was reviewed and approved on August 15, 2014. This project is approved until May 31, 2015.

You have been given permission to conduct surveys and collect de-identified grades and retention data on students in the identified sections of Biology for the fall term of 2014 as specified in the submitted IRB.

Good luck to you in conducting this research project. If you have questions or concerns, please contact me at 662-862-8265 or at lizados@iccms.edu.

Sincerely yours,

Liz Edwards
Director of Institutional Research, Effectiveness, & Accountability
APPENDIX K

THE UNIVERSITY OF SOUTHERN MISSISSIPPI
AUTHORIZATION TO PARTICIPATE IN RESEARCH PROJECT

Participant’s Name: ____________________________________________________________

I hereby give my consent to participate in the research project entitled Novelty or
Knowledge? A study of using student response system in non-major biology courses at a
community college. All procedures and/or investigations to be followed and their
purpose, including any experimental procedures, were explained by Tasha Thames.
Information was given about all benefits, risks, inconveniences, or discomforts that might
be expected.

The opportunity to ask questions regarding the research and procedures was given.
Participation in the project is completely voluntary, and participants may withdraw at
any time without penalty, prejudice, or loss of benefits. All personal information is
strictly confidential, and no names will be disclosed. Any new information that develops
during the project will be provided if that information may affect the willingness to
continue participation in the project.

Questions concerning the research, at any time during or after the project, should be
directed to Tasha Thames at (662) 862-8359. This project and this consent form have
been reviewed by the Human Subjects Protection Review Committee, which ensures
that research projects involving human subjects follow federal regulations. Any
questions or concerns about rights as a research participants should be directed to the
Chair of the Institutional Review Board, The University of Southern Mississippi, 118
College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266.6820.

A copy of this form will be given to the participant.

________________________________________  ______________  ____________
Signature of participant      Date

_________________________________________  ________ ____________
Signature of person explaining the study   Date
APPENDIX L

INFORMED CONSENT LETTER

Dear Research Participant:

The purpose of this research is to investigate whether the implementation of clicker technology would have any effect on student achievement and retention. You are being asked to participate in this research if you are eighteen years of age or older and enrolled in the Principles of Biology I class at Itawamba Community College. Participation in this research does not require extra out of class time for studying or assignments. By volunteering to participate, there is no risk other than that accompanying day-to-day activity.

Research has proven that students of the net generation not only believe technology is important, but also believe it can affect the way they learn. Because I believe all students can learn if provided the proper tools, you are being asked to volunteer for this research. By agreeing to participate, you will allow analysis of your pre-test and post-test scores. Pre-tests will be given at the beginning of the semester before implementation of clicker technology and post-tests will be given at the end of the semester after the implementation of clicker technology. The data collected from this study will be used to improve our college’s stance on technology in the classroom.

Confidentiality is of utmost importance. For this reason, you will be given a code to place on documentation so names will be unnecessary. This code will in no way be personally identifying. All data, electronic and written, will be kept in a secure locked location with electronic data also being encrypted.

Since participation throughout the study is voluntary, you may withdraw at any point without apprehension of penalization. Please feel free to email tmthames@iccms.edu or call (662) 862.8359 with any questions regarding this ongoing research. If you are willing to participate in this research described above, please complete the attached letter of consent and return immediately.

This study has been examined by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-6820.

Thank you,
Tasha Thames
APPENDIX M

SAMPLE CONCEPT TEST QUESTIONS FROM ALL FOUR UNITS

1. A sample of concept test questions from all four units:

   - A sample hypothesis is a statement that...
   - A hypothesis should be tested through...
   - A hypothesis is the same as a theory...
   - Hypothesis is a testable prediction.

2. Compare a hypothesis and a theory:

   - A hypothesis is a tentative explanation of a phenomenon. A theory is a well-substantiated explanation of some aspect of the natural world that is supported by a body of facts and/or laws that have been critically tested and confirmed.
   - A hypothesis is a testable prediction. A theory is a set of well-substantiated explanations of a phenomenon that have been tested and confirmed.
   - Both a hypothesis and a theory are predictions.
   - Both a hypothesis and a theory are well-substantiated. Which of the following is not a testable prediction? a) A hypothesis. b) A theory. c) Both hypothesis and theory. d) Neither hypothesis nor theory.

3. You decide to test the effect of vitamin C on growth of plants. Vitamin C is given to two groups of plants. One group is given vitamin C and the other is given a placebo. Which of the following is a control group? a) Both groups. b) Only the placebo group. c) Only the vitamin C group. d) Neither group.

4. ____ are small molecules that are put together to make large molecules called ______.

   - Lipids, amino acids, nucleic acids, carbohydrates

5. The monomer in a carbohydrate is:

   - Glucose, amino acids, nucleic acids, lipids

6. The monomer in a lipid is:

   - Glucose, amino acids, nucleic acids, lipids

7. The monomer in a nucleic acid is:

   - Glucose, amino acids, nucleic acids, lipids

8. The monomer in a protein is:

   - Glucose, amino acids, nucleic acids, lipids

9. Unlike a prokaryotic cell, a eukaryotic cell:

   - Has a nucleus, has mitochondria, has a cell membrane, has ribosomes

10. Which two organelles are responsible for protein synthesis?

    - Nucleus, mitochondria, endoplasmic reticulum, ribosomes

11. Which organelle modifies and packages proteins for export?

    - Nucleus, endoplasmic reticulum, Golgi apparatus, lysosomes

12. Which organelle is NOT true about the cell membrane?

    - Fluid mosaic model, composed of phospholipids and proteins, selectively permeable, regulates the movement of substances in and out of the cell

13. Which organelle is true about the cell membrane?

    - Fluid mosaic model, composed of phospholipids and proteins, selectively permeable, regulates the movement of substances in and out of the cell
A sample of Concept test questions from all four units of non-major Biology class

1. Compare a hypothesis and a theory:
   A. A hypothesis is supported by many types of evidence and a theory is a prediction
   B. A hypothesis is a prediction and a theory is supported by multiple types of evidence
   C. Both a hypothesis and a theory are predictions
   D. Both a hypothesis and a theory are educated guesses

2. You decide to test the effects of Miracle Grow fertilizer on plant growth. Group A is given fertilizer once a week for 4 weeks. Group B is given no fertilizer. The plant height of both groups is measured daily. Which of the following is a possible source of error?
   A. Group A has 2 plants and Group B has 10 plants
   B. Group A is kept in the sun and Group B is kept in the shade
   C. Group A is given 100 ml of water each day and Group B is given 50 ml of water each day
   D. All of the above

3. You decide to test the effects of Miracle Grow fertilizer on plant growth. Group A is given fertilizer once a week for 4 weeks. Group B is given no fertilizer. The plant height of both groups is measured daily. Why is it necessary to have Group B as your control group?
   A. The control group makes your results invalid
   B. The control group is a possible source of error
   C. The control group is used for comparison
   D. None of the above

4. _____ are small molecules that are put together to make large molecules called _____.
   A. Monomers, polymers
   B. Polymers, monomers
   C. Monomers, polygons
   D. Polymers, amino acids

5. The monomer in a carbohydrate is:
   A. Amino acids
   B. Nucleic acids
   C. Monosaccharides
   D. Glycerol & Fatty Acid

6. The monomer in a Lipid is:
   A. Amino acids
   B. Nucleic acids
   C. Monosaccharides
22 Which of the following are reactants of photosynthesis
   A. Carbon dioxide & Glucose & Light
   B. Carbon dioxide & Water & Light
   C. Oxygen & Water
   D. Oxygen & Glucose

23 Which of the following are products of Photosynthesis?

24 The pigment that absorbs red and blue light and reflects green light in Photosynthesis is
   A. Carotenoid
   B. Melanin
   C. Zanthophyll
   D. Chlorophyll

25 The main energy molecule used by cells is:
   A. ADP
   B. Oxygen
   C. NADH
   D. ATP

26 In Cellular Respiration, ________ is broken down to make energy.
   A. Glucose
   B. ATP
   C. Water
   D. Carbon Dioxide

27 Cellular Respiration occurs in the:
   A. Chloroplast
   B. Mitochondria
   C. Lysosome
   D. Ribosome

28 Which of the following is NOT a function of DNA (Genes) in the cell?
   A. Carry information from one generation to the next
   B. Code for proteins
   C. To determine inherited traits
   D. To control all cell activities
REFERENCES


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large lecture classes. *Contemporary Educational Psychology, 34*(1), 51-57.


Doi: 10.1080/17439880601141179


