THE IMPACT OF CLASSROOM PERFORMANCE SYSTEM-BASED INSTRUCTION WITH PEER INSTRUCTION UPON STUDENT ACHIEVEMENT AND MOTIVATION IN EIGHTH GRADE MATH STUDENTS

by

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A Dissertation Presented in Partial Fulfillment Of the Requirements for the Degree Doctor of Education

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ABSTRACT

Tracy Michelle Hunter Allison. THE IMPACT OF CLASSROOM PERFORMANCE SYSTEM-BASED INSTRUCTION WITH PEER INSTRUCTION UPON STUDENT ACHIEVEMENT AND MOTIVATION IN EIGHTH GRADE MATH STUDENTS.


The researcher employed two designs to address the research question for this particular study. This quasi-experimental non-equivalent control group study compared the math achievement of 92 eighth grade students who received Classroom Performance System (CPS)-based instruction using Peer Instruction (PI) to 76 eighth grade students who received CPS-based math instruction without PI. Posttest scores were statistically analyzed using an ANCOVA. Iowa Test of Basic Skills scores were used as a covariate. A statistic control group design was employed to examine student motivation for the same group of students under the same conditions. Student motivation data from the Instructional Materials Motivation Survey (IMMS) were statistically analyzed using MANOVA and independent sample t-tests. The results showed that eighth grade students who received CPS-based math instruction using PI had significantly higher math achievement scores. Student motivation scores were statistically higher when analyzing all four components of the IMMS together. When analyzing the components separately, two of four subscales were significantly higher for the treatment group.
Dedication

To my wonderful husband, Chris, who is the love of my life and the man with whom I look forward to sharing the rest of my life: Thank you for your patience, support, understanding, love, and help throughout this long endeavor as well as during all the other difficult situations that life has thrown our way, yet we have endured together over the years. I could not have done this without you, and I love you so much. Thank you for being both mom and dad so many times, all the clothes you have washed, all the meals you have cooked, and all the dishes you have cleaned. Thank you for all the times you allowed me to work on my dissertation and spent time with our kids when I felt so guilty about having to work instead of being a mom.

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List of Abbreviations

AYP – Adequate Yearly Progress
CBM – Curriculum Based Measurement
CPS – Classroom Performance System
GPS – Georgia Performance Standards
IMMS – Instructional Materials and Motivation Survey
ITBS – Iowa Test of Basic Skills
NCLB – No Child Left Behind
PI – Peer Instruction
SBC – Standards Based Classroom
CHAPTER ONE: INTRODUCTION

Background

Twenty-first century learners expect instructors to utilize the technological tools available to create an active learning environment where they can interact with the material, the instructor, and their peers (Prensky, 2008). They no longer respond to instructors who use the strictly traditional, instructor-led, lecture-based approaches of the past (Duncan, 2006; Prensky, 2008). The No Child Left Behind Act (NCLB) of 2001 mandates that educators raise academic achievement each year until the year 2014 when 100% of students are expected to meet adequate yearly progress (AYP) (No Child Left Behind [NCLB], 2002). Classrooms that implement active learning may be more likely to produce students capable of reaching that standard (Florida State University Office of Distance Learning, 2011; Michael, 2006).

Educators can work toward meeting the NCLB mandates by determining which technologies and teaching strategies will enhance the learning environment in a way that increases not only student engagement and motivation, but also academic achievement. With so many choices available today, educators must be diligent in their quest for technological tools and teaching strategies that will meet these challenges.

Many studies conducted at the postsecondary level have found that the implementation of a Classroom Performance System (CPS), sometimes referred to as clickers, is one way to incorporate technology in today’s classrooms in order to engage students (Bruff, 2009; Duncan, 2005; Gauci, Dantas, Williams, & Kemm, 2009). The use
of such technology is becoming more prevalent at the collegiate level and in K–12 schools as well. The term CPS refers to a wireless electronic response system that uses remote control devices to allow an entire class to give immediate feedback to teachers and students, thus allowing an instructor to quickly ascertain individual student academic needs and modify instruction as needed (eInstruction, 2011).

Several meta-analyses and literature reviews address the use of CPS in the classroom (Barber & Njus, 2007; Cain & Robinson, 2008; Caldwell, 2007; DeGange, 2011; Fies & Marshall, 2006; Judson & Sawada, 2002; Kay & LeSage, 2009; Keller et al., 2007; MacArthur & Jones, 2008; Simpson & Oliver, 2007; Stowell & Nelson, 2007). These nine meta-analyses and literature reviews provide much information about a variety of topics related to the use of CPS in the postsecondary classroom, some of which may be generalized to the K–12 classroom setting.

While many testimonials and anecdotal articles are available online, little quantitative research is available in peer-reviewed journals about the use of CPS in the K–12 classrooms in comparison to the amount of literature available about the use of CPS in the postsecondary classroom. The researcher found five doctoral dissertations about the use of CPS in the K–12 classroom (Lively, 2010; Musselman, 2008; Rigdon, 2010; Sartori, 2008; Shirley, 2009). Much research is available about teacher and student perspectives on the use of CPS in postsecondary institutions (Ainuson, 2008; Fies & Marshall, 2006; Graham, Tripp, Seawright, & Joeckel, 2007; Holmes, Blalock, Parker & Haywood, 2006; Jackson, 2007; MacGeorge et al., 2008; May, 2007; Wood, 2004). The researcher located one master’s thesis about student motivation of elementary students concerning the use of CPS; however, Peer Instruction (PI), a specific teaching strategy
that can be implemented with or without the use of CPS, was not a variable used in the study (Thomsen, 2006). Van Dijk, Van den Ber, and Van Keulen (2001) researched the effects of active learning and the use of CPS and PI on learning and student motivation in a collegiate engineering class. Cutts, Carbone, and Van Haaster (2004) researched the effects of PI in a postsecondary setting regarding the effects on learning due to clarifying student misconceptions.

It is unclear whether CPS increases learning outcomes, or if it is just the latest in a line of educational novelties that is currently en vogue. Research indicates that the use of a CPS seems to motivate college students (Gauci et al., 2009; Radosevich, Salomon, Radosevich, & Kahn, 2008). However, the researcher wanted to determine if the implementation of such technology actually increases learning outcomes and motivation for K–12 students.

According to Penuel, Boscardian, Masyn, and Crawford (2007):

Researchers who have studied student response systems in higher education share a belief that the technology alone cannot bring about improvements to student participation in class and achievement; rather, the technology must be used in conjunction with particular kinds of teaching strategies. (p. 318)

CPS technology, when used along with research-based teaching practices, may have a positive impact on student learning and student engagement (Jones, 2009; Mazur, 1997). One such teaching strategy is PI.

Eric Mazur (1997, 2001) developed a pedagogical technique, PI, in which instructors purposefully design instruction that allows students to work collaboratively with their peers. After the instructor poses a question to the class, the students must
determine the answer to the question. Students must then work with at least one partner in which they must try to convince their peers that their answer to the given question is correct. Students must provide a rationale to their peers for why their answer is correct. Thus, students learn from each other by explaining content to their classmates. The PI strategy involves active learning, questioning techniques, peer discussions, student-centered instruction, and formative assessment, with frequent or immediate feedback that helps drive the instruction. Much research regarding the use of PI has been conducted at the collegiate level (Crouch & Mazur, 2001; Duncan, 2005; Fagen, Crouch, & Mazur, 2002; Lasry, Mazur, & Watkins, 2008; Lucas; 2009; Turpen & Finkelstein, 2007). K–12 teachers may know this term by a related name such as the cooperative learning strategy called think-pair-share or peer discussion (Engaging Technologies, 2008). In an effort to ascertain if CPS technology actually enhances student learning at the middle school level, the researcher wanted to (a) examine student achievement in relation to the implementation of a CPS with PI and without PI in a middle school and (b) examine student motivation in relation to CPS implementation with PI and without PI in a middle school.

The researcher found many articles relating to the use of CPS and math at the collegiate level (Blodgett, 2006; Bode, Drane, Kolikant, & Schuller, 2009; Butler, 2005; Butler & Butler, 2006; Cline, 2006; Cline, Zullo, & Parker, 2007; d’Inverno, Davis, & White, 2003; King & Robinson, 2009a, 2009b, 2009c; Lomen & Robinson, 2004; Miller, Santana-Vega, & Terrell, 2006); however, none of these studies included the use of PI nor focused on student motivation. One study (Lucas, 2009) did include PI as a variable in his study on the use of CPS in a math course at the collegiate level.
Problem Statement

Fostering meaningful learning and motivation among students is a long-standing concern for all educators. Currently, all educators are faced with adapting their teaching styles to the learning styles and needs of the “Net Generation,” students who have grown up in a digital world and who have different needs than students in the past (Prensky, 2008; Skiba & Barton, 2006). Students expect classrooms to be interactive and engaging. Today’s educators are also faced with ever decreasing budgets due to difficult economic conditions coupled with ever increasing accountability demands from local, state, and national mandates such as NCLB’s high-stakes testing and requirements for meeting AYP. NCLB (2002) insists that all students make gains in achievement and that all students perform at or above grade level by 2014. Administrators and teachers are charged with providing instruction and engaging learners in a learning environment that produces high levels of academic achievement. Educators are expected to make sound theoretical and research-based decisions regarding how to teach students (Kelly, 2011). CPS may be a tool that helps educators accomplish this goal.

Over the past 10 years, CPS has been used as a technological tool for increasing student engagement in postsecondary classrooms, but little research has been conducted to measure its effectiveness in K–12 classrooms (Lively, 2010; Musselman, 2008; Rigdon, 2010; Sartori, 2008; Shirley, 2009). With the United States mired in an economic crisis and school system budgets feeling the impact of this crisis, research is needed to determine if the purchase of a CPS is a wise use of limited funds.
This study was designed to address the problem of whether or not using CPS-based math instruction in conjunction with a specific pedagogy (i.e., PI) can positively affect student achievement and student motivation in K–12 classrooms.

Purpose Statement

The purpose of this study was to determine the impact of student use of a CPS technology, supported with a PI strategy, on the academic achievement and motivation of eighth grade math students. The researcher collected and analyzed the posttest data of the participants. A student motivation survey, the Instructional Materials Motivation Survey (IMMS), was distributed at the end of the study to gather self-reported student motivation data about the use of CPS technology with and without PI.

The researcher and other professionals may use the results of the study in order to justify the use of CPS in their classrooms. The goal was to provide information gleaned from this research project to benefit other educators in the target school as well as other schools in the district. For educators already using CPS, the researcher hoped to provide effective models of CPS use that will make their implementation more effective in the classroom.

Significance of the Study

There is a gap in the literature in regards to the effectiveness of CPS and PI in middle schools. The findings of this study will contribute to filling that gap. Research on the K–12 classroom regarding CPS use and PI in the K–12 classroom is extremely limited in published literature. Most available information about CPS relating to the K–12 classroom is anecdotal in nature and only available in a limited number of dissertations. Fies and Marshall (2006) indicate that additional research is needed to
investigate different conditions of CPS use across a variety of settings. There is clearly a need for additional research in regard to CPS and various aspects of use in the K–12 classroom (Lively, 2010; Musselman, 2008; Rigdon, 2010; Sartori, 2008; Shirley, 2009). There is also a need for further research about student motivation in the K–12 classroom (Dorr, 2006). The literature concurs that additional research is necessary regarding the use of CPS technology in conjunction with a distinct theoretical framework as well as in a variety of learning environments (Albon & Jewels, 2007; Jones, 2009).

This study will help administrators and teachers in the target school determine the impact of CPS, with and without PI, on student math achievement and student motivation. Other schools in the target district or nearby areas that use or anticipate using CPS technology could benefit from this research as well. Educators could use the findings of this study to help decide whether or not to adopt or modify the use of CPS in classrooms at all levels to better meet the needs of students and increase student achievement and student motivation.

**Research Questions and Hypotheses**

The following questions and hypotheses guided the researcher in this project:

Research Question 1: Is there a difference in student achievement mean scores between eighth grade students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based math instruction without PI, as measured by the expert-validated Unit 7 math posttest?

Null Hypothesis 1: There is no statistically significant difference in the mean scores on the expert-validated Unit 7 math posttest between eighth grade students who receive CPS-based math instruction with PI as opposed to those who receive CPS-based
Research Question 2: Is there a difference in motivation mean scores between eighth grade math students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based math instruction without PI, as measured by the Instructional Materials Motivation Survey (IMMS).

Null Hypothesis 2a: There is no statistically significant difference in the linear combination of motivation subscale mean scores between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive Classroom Performance System-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2b: There is no statistically significant difference in the mean scores of the attention subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2c: There is no statistically significant difference in the mean scores of the relevance subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2d: There is no statistically significant difference in the mean scores of the confidence subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.
Null Hypothesis 2e: There is no statistically significant difference in the mean scores of the satisfaction subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Identification of Variables

The independent variable in this study was the CPS-based pedagogy PI, implemented during the unit of study. The treatment group used a CPS with PI while the control group used only a CPS. The two dependent variables were math achievement and student motivation concerning the use of the CPS with or without PI. Math achievement was measured by scores on an expert-validated end-of-unit math assessment. Student motivation was measured by using the IMMS (Keller, 2010b).

Overview of Methodology

The researcher determined that a quasi-experimental pretest-posttest nonequivalent group design was appropriate to answer research questions (Creswell, 2005), and a static group design was appropriate to answer research question 2. The research participants for this study included all eighth students in one rural, public middle school in northeast Georgia. A total of 168 students participated in the study. There were 92 students in the treatment group and 76 in the control group. Two eighth grade middle school math teachers were involved in the study. One teacher used PI pedagogy along with CPS instruction (treatment group), and one teacher used CPS instruction without PI (control group).

Both the treatment group and the control group received the same instruction for one unit of academic study (approximately four weeks). CPS was used at least twice per
week and incorporated approximately five questions during each use. Students in both groups received formative and summative feedback on a weekly basis through the use of a CPS (e.g., instant visual feedback, histograms). An end-of-unit posttest was administered along with an online student motivation survey, the IMMS, at the end of the study. The student achievement data from the posttest were analyzed using both descriptive statistics and a one-way analysis of covariance (ANCOVA). Student motivation data were analyzed using a multivariate analysis of variance (MANOVA) to simultaneously analyze all components of the IMMS and multiple independent sample t-tests to analyze each motivation subscale separately. The findings of this study are presented and discussed in Chapter Four.

Definitions of Terms

Classroom performance system (CPS): CPS refers to a hardware/software system that allows instructors to pose multiple-choice questions and receive instantaneous feedback using remote control response pads, a computer projection device, a portable receiver, and response analysis software (eInstruction, 2011).

Clickers: The term clickers refer to an electronic student response system. This term is another name for CPS. This term sometimes refers to the remote control used with a CPS (eInstruction, 2011).

Formative assessment: This type of assessment is part of the instructional process. Formative assessment provides the instructor real-time information needed to alter teaching methods and provides both instructors and students with information about students’ understanding of the material at a time when judicious changes can be made to the instruction (Garrison & Ehringhaus, 2007).
*Georgia Performance Standards (GPS):* The GPS is a state-mandated curriculum for each academic subject area in grades K–12 that tells the teacher what the student is expected to know and be able to do (Georgia Department of Education, 2011a, 2011b).

*Peer Instruction (PI):* PI is a pedagogical technique developed by Eric Mazur, a physics professor at Harvard University, in which students learn from each other by explaining content to their classmates or peers and then trying to convince their peers that they are correct and the reasons that they are correct (Mazur, 1997).

*Study Island:* Study Island is a web-based software program designed to correlate with state-mandated curriculum for many states including Georgia. For a fee, this program can be used by individual students or as a whole class when an electronic response system such as CPS is incorporated (Study Island, 2011). For the purposes of this study, it was used in conjunction with CPS to facilitate the use of questions given to students.

*Summative assessment:* Summative assessment is part of the instructional process. Summative assessment provides information to the instructor at the end of a unit of instruction or course so that adjustments may be made to the curriculum or assessment the next time the material is presented or assessed by the instructor (Garrison & Ehringhaus, 2007).

*Survey:* For the purpose of this study, a survey refers to the online set of questions in the IMMS. The questions were administered to student participants as a self-reflection of their own learning and motivation as a result of the use of CPS using or not using PI (Cherry, 2011; Keller, 2010a).

**Summary**
The use of technology in the classroom is one way to engage and motivate students. When used in conjunction with a specific pedagogy, such as PI, the use of a CPS has been shown to increase student achievement at the collegiate level. Since few studies have been conducted in the K–12 arena regarding the use of CPS, this study was designed to determine if CPS used in conjunction with PI has a positive impact on student achievement and student motivation in eighth grade students. This quasi-experimental quantitative study employed a posttest nonequivalent group design.

Chapter 2 examines the theoretical framework and relevant literature that supports the study. Active Learning Theory and the ARCS Motivation Model are explored, along with CPS and PI.
CHAPTER TWO: REVIEW OF THE LITERATURE

This review of the literature will present information on the implementation of a Classroom Performance System (CPS) with a research-based pedagogy, Peer Instruction (PI). The impact of the implementation of CPS-based instruction on student achievement and student motivation in the classroom will be explored. Theory regarding pedagogy used in the classroom in conjunction with a CPS will be included, along with information about the implementation of PI.

Fostering meaningful learning and motivation among students is a long-standing concern for all educators. Currently, educators are faced with adapting their teaching styles to the learning styles and needs of the Net Generation, students who have grown up in a digital world and who have different needs than students in the past (Prensky, 2008; Skiba & Barton, 2006). Today’s educators are also faced with decreasing budgets due to difficult economic conditions coupled with increasing accountability demands from local, state, and national mandates such as NCLB (2002) regarding high-stakes testing and requirements for meeting AYP. Because of these demands educators need to make sound theoretical and research-based decisions when teaching students (Kelly, 2011). The purpose of this study was to determine the impact of CPS-based instruction when used with PI on student achievement and motivation of eighth grade math students.

Review of the Related Literature

As recommended by Johnson and Christensen (2008), the researcher began a focused search of the literature concerning CPS, PI, and theoretical frameworks by reviewing two primary sources of information, books and journals, which were relevant
to the research topic. In addition, the researcher reviewed information found in computer databases such as EBSCOhost, ERIC, and ProQuest to find peer-reviewed journals, technical reports, academic theses and dissertations. The researcher found many more articles related to the postsecondary use of CPS and PI than were available on CPS and PI use in the K–12 setting. Additionally, the researcher obtained some information relating to the student survey used in the research via personal email communication with the author of the survey. Finally, the researcher was also able to find some articles related to the research topic by using the Internet, being careful to use criteria suggested by Johnson and Christensen (2008) to locate articles that appeared to provide credible and accurate information. The researcher ultimately focused the search for literature primarily on peer-reviewed articles and websites related to the research topic because of the constant changes relating to technology, the increasing availability of information online related to technology, and the fact that very few books have been written about CPS or PI.

The researcher conducted Boolean keyword searches of peer-reviewed literature available primarily from online databases and the Internet. The searches focused on the researcher’s quest to find literature about the use of a CPS and the use of PI along with a possible impact on student achievement and motivation in the middle school math classroom. The researcher found it challenging to locate articles related to the focus of the research due to the wide variety of names that educators use when referring to this type of technology. The researcher used general terms including classroom performance system, clickers, pedagogy, peer instruction, student achievement, student motivation, student perceptions, teacher perceptions, middle school classroom, mathematics, surveys, Instructional Materials Motivation Survey, John Keller, ARCS Model of Motivational
Design, K–12 education, meta-analysis, literature review, and theoretical frameworks. These searches resulted in a multitude of articles. However, many of the located articles were not relevant to the proposed research. In an effort to reduce the search results to include only articles pertinent to the goal of the proposed study, the researcher performed a more concentrated search by varying the combination of the previously listed general terms. At this point, limited results were returned, and they indicated a possible gap in the literature in regards to CPS using PI pedagogy in a middle school classroom and how they impact student achievement and motivation.

A review of the literature yielded multiple meta-analyses or literature reviews pertaining to CPS and related topics. Electronic response systems such as CPS have been utilized in postsecondary classrooms since the 1960s (Deal, 2007). In the past decade, CPS has become popular in the K–12 classroom as well. In fact, one manufacturer of CPS technology, eInstruction, purports that their company has sold over one million sets of CPS to schools that house K–12 classrooms (eInstruction, 2011). Accordingly, much research has been conducted about various aspects of CPS and PI respectively; however, most of the research has been conducted at the collegiate level.

Judson and Sawada (2002) provided an historical summary of CPS use prior to 1998 in postsecondary classrooms, thus most of this review is dated. The researchers analyzed 11 peer-reviewed articles, seven conference reports or proceedings, one website, two books, and three dissertations relating to ARS.

Fies and Marshall (2006) completed an analysis of methods used to assess CPS with a focus on the benefits and limitations of such technology. In addition, the researchers examined 23 peer-reviewed studies, which included only three articles that
were published after 2004. Therefore, much of the information in this literature was outdated even at the time of publication.

Barber and Njus (2007) analyzed 12 peer-reviewed pieces of literature, including other literature reviews relating to CPS, in order to compare the characteristics, benefits, challenges, and drawbacks of six leading brands of radio-frequency CPS systems. Barber and Njus’ research can be used to help provide information to those people preparing to select an appropriate CPS system.

Caldwell (2007) analyzed 40 peer-reviewed articles, seven conference articles, five books, and two website articles related to CPS. The researcher examined the literature on CPS as applicable to large-enrollment classes and summarized the best practices for CPS use and student and faculty attitudes. She also discussed the successes, outcomes, and challenges of this technology based upon educational research.

Simpson and Oliver (2007) completed a two-stage review in 2002 and 2006 of the literature relating to CPS. The researchers analyzed more than 40 pieces of literature. Twenty-six of the cited articles were from peer-reviewed journals, 14 were from conferences or proceedings, and six were from websites. Six of their references were books of educational theory relating to learning or CPS. The researchers identified six themes in their review of the literature concerning CPS: environments in which CPS is used, reasons or rationale for use, pedagogy, impact on the staff, organizational issues, and student perceptions.

MacArthur and Jones (2008) completed an extensive review of 71 peer-reviewed journal articles, seven websites, 14 conference papers, and three books relating to the use
of CPS. The researchers discussed the benefits and drawbacks of the technology as well as pedagogy that are effective in using CPS.

Cain and Robinson (2008) examined the literature in 30 peer-reviewed studies and two conference papers regarding CPS. The authors focused on the issues, benefits, potential uses, and future areas of educational research of CPS instructional strategies in relation to the health profession and more specifically to pharmacy education.

Kay and LeSage (2009) analyzed 67 peer-reviewed articles ranging from 2000 to 2007. The articles related to CPS research at the collegiate and professional level in the medical field. Fifty-nine of those articles focused on math and science. The researchers reviewed 26 terms used synonymously to identify CPS technology, which reinforces the difficulty in finding and comparing literature regarding this topic. They discussed the benefits and challenges of using this technology for both teachers and students. They proposed that future research should center around (a) determining why certain benefits and challenges affect the use of CPS, (b) analyzing the impact of certain types of questions used with the technology, (c) conducting research in a broader range of environments and subject areas, and (d) revealing individual differences in the use of this type of technology (i.e., gender, grade levels, age, learning style, etc.).

Finally, De Gange (2011) examined 15 peer-reviewed studies on how CPS can best be used to promote learner engagement and how to improve classroom education in order to provide more effective and efficient instruction as it relates to nursing education. The researcher focused on formative assessment, learning outcomes, student participation, student interactivity, and student satisfaction (De Gange, 2011).
This review of the available literature on integration of a CPS in middle school includes a limited number of articles that discuss CPS used in K–12 schools as compared to articles pertaining to the use of CPS at the postsecondary level (Lively, 2010; Musselman, 2008; Rigdon, 2010; Sartori, 2008; Shirley, 2009). Even most of these included studies attempted to focus on whether or not CPS was used in the study, and not on the pedagogy involved. However, “The field of educational technology is under external pressure to provide evidence of identifiable learning outcomes that can be attributed to technology” (Schrum et al., 2007, p. 1). The debate about the use of technology seems to be between the idea that technology is just an instructional delivery mechanism (Clark, 1983; Rich, 2007; Schrum et al., 2007) and the idea that technology is an end unto itself (Kozma, 1991).

Research on CPS suggests that this technology promotes learning when accompanied with research-based pedagogy (Adams & Howard, 2009). The researcher believes that using CPS-based instruction with PI will improve student motivation and, ultimately, student achievement in the middle school classroom. Kelly (2011) stated, “The field of education is changing and new theories and teaching methods can make all the difference in the world for new, struggling, and even experienced teachers” (para. 7). However, with today’s economic hardships, funding for technology as well as staff development funds for teaching educators how to use this technology are two of the first areas to be cut from the budget (Kelly, 2011).

**Conceptual or Theoretical Frameworks**

Roblyer (as cited in Schrum et al., 2007) noted, “The field of educational technology currently lacks a clear theoretical foundation as a framework for research”
(para. 1). Beatty and Gerace (2009) found CPS to be a promising instructional technology, despite the inability of researchers to distinguish CPS technology from CPS pedagogy. Several different theoretical frameworks can be found in the literature related to the integration of various electronic response systems. These learning theories are known as standards based classroom, active learning, Sociocultural Learning Theory, and Constructivism.

**Standards based classroom.** In an effort to rise to the challenge of national, state, and local mandates to improve the quality of education in all classrooms, educators are expected to maintain a Standards Based Classroom (SBC). According to the Georgia Department of Education (2011b), a SBC is one in which the curriculum, instruction, student learning, and assessment are specifically aligned to a given set of academic standards. In Georgia classrooms, these academic standards are the Georgia Performance Standards (GPS). The GPS identify specific content and align the curriculum both horizontally and vertically for each grade and subject area in grades K–12. The premise of a SBC is that all students will have access to clearly communicated and understood standards, and that all students will produce evidence of high levels of learning and academic rigor. Thus, the teacher knows exactly what is to be taught, and the teacher and student know and can communicate specifically what the student should know and be able to do. The teacher will provide remediation and/or enrichment based upon the data from the frequent formative assessments. In this type of well-designed instruction, teachers plan collaboratively with subject area/grade level peers, teach, assess, and reteach based upon assessment data. An important component of SBC teaching is frequent meetings with same grade level and subject area teachers in order to discuss
assessment data, make adjustments in teaching or reteaching content, and tweak or redesign the assessment. Assessment is one of the most important components of the SBC, and must expressly measure the standards that are being taught.

SBC design is very structured. Every classwork assignment, homework assignment, project, or test should relate to a specific standard or set of standards that has been expressly taught. The class normally starts with a reference to the standard that is being taught, as well as a discussion of an essential question that students should be able to answer by the end of the class or unit, which is based on that previously-stated standard. Throughout the instructional period, the teacher and the students should make frequent references to the standard and use specific language from the standard. After a brief teacher- or student-centered instructional period, there is a clearly defined work period followed by some type of closure and/or brief formative assessment. Using instructional technology in the SBC is recommended in order to help promote active learning (International Society for Technology and Education, 2000; Palak & Walls, 2009).

**Active learning.** Active learning is referred to in many research articles that discuss the use of electronic response systems (Hoffman & Goodwin, 2006; Martyn, 2007; Paschal, 2002). Active learning, often associated with Bruner (1961), refers to engaging students’ minds in the learning process. Research indicates that students who are actively engaged in their learning will grasp and retain more information, thus resulting in deep learning (Berry, 2009; Moredich & Moore; 2007; Trotter, 2005). Phil Schlechty (2002) and The Schlechty Center have completed much work regarding the importance of student engagement and its affect upon student achievement. Additional
research by Fies and Marshall (2006) indicated that the benefits of CPS most commonly seen at the postsecondary level were students’ perceptions of class being more fun and engaging, and both instructors and students becoming more aware of the level of the students’ understanding.

According to the Center for Teaching Excellence (2009) at Virginia Commonwealth University, the use of CPS has great potential for creating a learning-centered, active classroom by:

1. providing frequent feedback to both students and professors on a daily basis.

2. exploring and exposing hidden misconceptions that both students and instructors may bring with them to class.

3. using it in conjunction with active learning techniques that are particularly suitable for large class settings.

4. surveying student attitudes, opinions, and behaviors.

5. informing instructors about the effectiveness of various teaching methods or learning activities.

Various researchers have coupled active learning and the integration of a CPS with positive results. Jones (2009) found that a student response system along with PI resulted in a positive impact on learning when used to facilitate active learning in large undergraduate courses. Results from Paschal (2002) indicate that learning physiology concepts is potentially more effective when in-class quizzes and activities are used in conjunction with instant feedback via a CPS rather than traditional learning activities such as passive lectures or homework. Berry (2009) engaged in research in postsecondary nursing classes using CPS with a focus on active learning teaching
methods, which resulted in increased student learning outcomes as well as student satisfaction. Gauci, Williams, and Kemm (2009) further added to the body of literature by investigating whether an active learning environment and the implementation of CPS resulted in improved learning and student engagement. Results indicated an increase in both student motivation and engagement as well as increases in exam scores. Radosevich et al. (2008) examined whether CPS impacted student motivation and fostered active learning. Results of the study showed that teachers who used the CPS as an integral part of classroom instruction performed better on a midterm exam, reported greater engagement in the class and higher expectations of success, and performed higher on a knowledge-retention test given at the end of the semester.

**Constructivism.** The Constructivist theory of learning based upon the ideas of Dewey, Vygotsky, and Piaget has been the foundational concept used by many researchers who have studied various types of classroom response systems. Funderstanding (2008) said that Constructivism in the classroom focuses on connections between facts and promoting awareness of learning in students. Constructivist instructors use strategies that are in tune to student questions and encourage students to analyze, interpret, and predict information. Constructivist teachers also use open-ended questions to promote student dialogue.

Constructivism is student-centered and sometimes called “discovery learning” because students are provided opportunities to construct knowledge through discovery, projects, or authentic learning (D’Angelo et al., 2011). In this model, students frequently work together in cooperative groups, and learners’ responses often guide the direction of the lesson and instructional strategies. The instructor acts more as a facilitator of learning
than as a traditional teacher who simply transfers information to his students. Active learning falls under the umbrella of the Constructivist learning theory.

Barnett (2006) states, “personal knowing is created by students in interaction with the material, other students, the instructor, their memories, and the world in general” (p. 2). Other researchers have advocated for Constructivist learning coupled with student-centered learning (Preszler, Dawe, Shuster, & Shuster, 2007), peer and classroom discussion (Penuel et al., 2007), self-managed learning experiences (Harper, 2009), and the use of PI (Wood, 2004).

**Sociocultural learning.** Another theory associated with the use of CPS instruction is the Sociocultural Theory. Penuel, Abrahamson, and Roschelle (2006) propose that Vygotsky’s Sociocultural Theory provides an explanation of the experiences and outcomes for students using electronic response systems because it addresses the issues of classroom interactions and dynamic structuring of the classroom. Sociocultural Theory states that learning cannot be separated from social interactions between individuals. A major aspect of PI is social interaction, which will be discussed later in this research.

**Student Motivation**

**Student motivation studies.** This review of the literature indicates that many studies are related to student motivation, which is a critical piece of the puzzle for educators seeking to improve student achievement. Teachers use a variety of pedagogical methods to engage and motivate their students. Motivating and engaging students can be difficult as many intrinsic and extrinsic elements and factors can affect student motivation and engagement. Muller, Eklund, and Sharma (2006) discussed the
implementation of technology in the classroom. These researchers suggested that classrooms that are already using successful intervention should be studied to discern what motivational techniques are being utilized, and then use that information to perform new intervention experiments. Research indicates that the use of a CPS seems to motivate college students (Gauci et al., 2009; Radosevich et al., 2008).

The motivational tactics used by teachers must lead to a mastery of the instructional goals. Entertainment is not the purpose of motivating students. The purpose is to promote learning (Keller, 2006a). CPS is a great way to maintain a high level of student motivation and involvement; lecturing destroys motivation and decreases attention to content (Duncan, 2005). Calhoun (n.d.) stated, “The use of a CPS is one technological tool that by its very nature motivates and engages students through active and cooperative learning” (para. 1). Beatty (2004) and McLoughlin (2008) stated that by engaging students’ minds in class that CPS-based instruction makes students active participants in the learning process. Teachers can sometimes utilize classroom management techniques or tools that are fun or promote positive feelings about the teacher or the course, but do not promote learning (Keller, 2006a). CPS can also be used as a fun tool for teachers to promote learning; however, sound and effective pedagogical methodology must be employed along with the use of CPS in order for student learning to take place. The goal of teaching with CPS is improved student learning, but many other benefits will be reaped for both teacher and student (Calhoun, n.d.). Unfortunately, many teachers do not even recognize improved student learning as the goal of using technology in the classroom, and definitely do not understand which pedagogy to use to accomplish that goal (Schrum et al., 2007). Student learning can certainly be impacted
positively using CPS if it is used to facilitate feedback, identify and correct student
preconceptions, and direct adjustments to teaching strategies (eInstruction, 2010).
However, to fully realize the potential of the CPS technology, an appropriate instructional
design should be utilized with the technology.

**ARCS model of motivational design.** Research is plentiful that indicates student
achievement and student motivation are paramount to student learning. However, the
age-old question of how to increase student motivation has concerned, frustrated, and
challenged instructors for years. Keller (1984, 1999) purports that instructors can
purposefully and systematically design instruction and manage the learning environment
to stimulate student motivation. Keller (1984) developed the ARCS model of
motivational design which can be used to help instructors purposefully design instruction
to encourage, promote, and increase student motivation. The ARCS model can be broken
down into four components related to the motivational requirements of learners:
attention, relevance, confidence, and satisfaction, all or part of which can be included in
instructional design in order to influence and motivate students to learn (Keller, 1987).
The four components were identified by Keller based upon a synthesis of research on
human motivation (Keller, 1999). The four components are referred to as principles
(Keller, 2008) and fundamental requirements (Keller, 2010a) in later research.

*Attention.* The first step in increasing student motivation is to acquire and
maintain the student’s attention (Keller, 1987, 1999). Keller (2008) defines attention as
gaining, building, and sustaining the curiosity of the learner in an activity.

*Relevance.* Once the teacher has gained the students’ attention, the second step in
increasing student motivation is to help the students understand the importance of the
lesson, to realize the personal connection of the topic, and to make the instruction meaningful or authentic to the learner (Keller, 1987, 2008). Keller (1987) defines relevance as satisfying the personal needs of the learner, which brings about positive results. Keller (1999, 2008) further asserts that relevance results from the instructor purposefully connecting the instructional content to the student’s personal learning goals, interests, learning styles, and experiences.

Confidence. The third step in increasing student motivation is to help build the student’s confidence (Keller, 1987). Some students can have too little or too much confidence, which can impact their level of motivation (Keller, 1987). Keller (1987) defines confidence as the learner’s belief that he/she has the ability to learn and to expect that he/she will be successful based on personal efforts.

Satisfaction. Last but not least, the fourth step in increasing student motivation is to ascertain student satisfaction with the learning process or the results of the educational experience (Keller, 1987). Keller (1987, 1999) defines satisfaction as the student’s personal sense of accomplishment through intrinsic or extrinsic rewards.

Keller (1987, 1999) provides practical instructional strategies that instructors can use to design instruction and generate ideas in order to help attain each of the four components related to motivation. Keller (1987, 1999) maintains that the attention component can be built into instruction by piquing the learner’s curiosity, using novel approaches to teaching, asking questions, and generating inquiry. Keller (2008) discusses the importance of varying one’s teaching strategies or techniques and pacing, as students will become bored with routine, no matter how interesting or novel the subject is at first.
Keller (1987, 1999) provided several instructional strategies for building the relevance component of student motivation into instruction. The instructor can explain learning objectives to students, provide individual learning opportunities, allow cooperative learning activities, use simulations when possible, and give concrete examples and analogies related to the students’ current interests.

Additionally, Keller (1987, 1999) provides suggestions for instructional strategies that incorporate the confidence component of student motivation into instruction. Instructors could provide and discuss a rubric in order to explain the learner expectations and grading criteria. Providing examples of quality student work also helps to build confidence. The instructor could incorporate a wide variety of challenging learning opportunities while providing multiple chances for individual success. Keller (1987, 1999) indicates that providing frequent feedback can build confidence.

Finally, Keller (1987, 1999) provides instructional strategies that can help build the satisfaction component of student motivation into instruction. Keller (1987, 1999) suggests that satisfaction can be built into student motivation by using real-life examples and problems; providing verbal praise, tangible rewards or incentives; or allowing the learners to share or affirm their efforts. It should be stressed that in order to build satisfaction, “Students must feel that the amount of work required by the course was appropriate” (Keller, 2008, p. 178), and that “there was internal consistency between objectives, content, and tests; and that there was no favoritism in grading” (Keller, 2010a, p. 308). This statement by Keller (2008, 2010a) supports the state-mandated SBC approach to teaching that is used in the classrooms at the research site.
Keller’s ARCS model of motivational design and his validated instrument developed for measuring motivation, the IMMS, have been used worldwide for many years and the validity confirmed in a variety of disciplines (Carson, 2006; Chan, 2009; Chen, 2011; Cheng & Yeh, 2009; Cook, Beckman, Thomas, & Thompson, 2009; Dunn, Rockinson-Szapkiw, Holder, & Hodgson, 2010; Gabrielle, 2003; Huang et al., 2004; Huett, Kalinowski, Moller, & Huett, 2008; Jaemu, Kim, & Lee, 2008; Jumanwan, 2011; Keller, 1997; Kim & Keller, 2008; Keller & Suzuki, 2004; Liao & Wang, 2008; Means, Jonassen & Dwyer, 1997; Rockinson-Szapkiw, Holder, & Dunn, 2011; Small, 2006; Small & Gluck, 1994; Visser & Keller, 1990; Yang, Tsai, Chung, & Wu, 2009).

Classroom Performance Systems

Much information has been presented in this chapter related to learning and instructional design theory. However, to this point, little information has been discussed about CPS itself.

Definition of a CPS. CPS has been used in many commercial and educational settings. CPS is a technological tool that affords instructors the ability to easily engage students in active learning (Duncan, 2005). CPS is often utilized in postsecondary classes (Beatty, 2004; Beatty & Gerace, 2009; Carnevale, 2005; Crouch & Mazur, 2001; Duncan, 2005) and is becoming more popular in K–12 schools as well. CPS technology allows and encourages all students to become active learners during instruction (Jones, 2009). Deal (2007) described CPS as an electronic system used to poll students and gather immediate feedback. Boyd (2003) said the benefit of a CPS is that it allows students to respond to questions without fear of verbalizing an incorrect answer. This is
possible because students give their answers to questions anonymously on a computerized keypad, as opposed to more risky response options.

**Various names for CPS.** Throughout the literature, the term CPS is used synonymously with many other technological expressions and abbreviations. Whatever term is utilized, researchers frequently refer to the CPS-type technology as CPS in their research. Because so many names are used extensively throughout the literature, it is often difficult to locate pertinent research articles. Also, it is often confusing to the reader when so many terms are used synonymously for the same technology. For consistency and clarity, the researcher used the term CPS throughout the research study. See Table 1 for a comprehensive, but certainly not exhaustive, compilation of various terms and the researcher(s) associated with those terms.

Table 1

**Various Names Used to Refer to Classroom Performance Systems**

<table>
<thead>
<tr>
<th>Term</th>
<th>Abbreviation</th>
<th>Researcher(s)</th>
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<tr>
<td>Audience Response Device</td>
<td>ARD</td>
<td>Salmon &amp; Stahl, 2005</td>
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<td>Audience Response System</td>
<td>ARS</td>
<td>Beatty, Leonard, Gerace, &amp; Dufresne, 2006</td>
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<td>Cain, Black, &amp; Rohr, 2009</td>
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Audience Response Technology  ART  Albon & Jewels, 2007
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MacGeorge et al., 2008
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<th>System</th>
<th>Code</th>
<th>Authors</th>
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<td>CCS</td>
<td>Beatty</td>
<td>2004</td>
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<td>Classroom Interaction System</td>
<td>CIS</td>
<td>Beuckman, Rebello, &amp; Zollman</td>
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<td>Classroom Performance System</td>
<td>CPS</td>
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d’Inverno et al., 2003
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Gustafson & Crane, 2005
Hoffman & Goodwin, 2006
Hudson, McGowan, & Smith, 2010
Jackson, 2007
Lucas, 2009
Nightingale, Palumbo, & Donahue, 2008
Roush & Song, 2011
Wit, 2003
Zahner, 2011

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<th>Personal Response Technology</th>
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<td>Personal Response Unit</td>
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<td>Question-based gaming technology</td>
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<td>Short Messaging Service Response</td>
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<td>Student Response Units</td>
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<td>Wireless Communication System</td>
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Note. Table based upon the work of Keong and Pieng (2008). Used with permission.

Implementation of a CPS. Research provides suggestions for implementation procedures for teachers who are just starting out with this type of technology. Kaleta and Joosten (2007) provided several implementation recommendations for those beginning to use CPS for the first time at the collegiate level that could apply to K–12 schools as well. These recommendations centered upon providing technical support for teachers and students, encouraging faculty to redesign their course several months ahead of teaching the course, negotiating the best price possible when students are required to purchase the remotes, and using only one brand of student response system.

Classroom performance systems are easy to set up and use. However, prior to use, instructors should receive training on how to use the technology and have a backup plan for technological support as needed. Duncan (2005) developed a list of ideas with corresponding explanations of how to best put those ideas into action. First, the teacher should set up the classroom to make it amenable to CPS use. To prepare a classroom for CPS use, the teacher should test the set of CPS using the technology in the setting where the CPS will be used. This should be done prior to the first use with students. Secondly, the teacher should have a clear set of goals in mind for CPS use and should plan in advance how CPS use will be graded and explain this grading process to the students. If the instructor’s goal is student participation, then partial credit should be given for incorrect answers. Third, the instructor should start with a few CPS questions per class and increase the number of questions as the instructor’s and student’s comfort level with
the technology increases. The level of questions used by the instructor must not be too simple or complex, relate to the standard(s) being taught in the course, and relate to questions that will be on an exam. Fourth, the teacher should be prepared for class and have a backup plan in the event that something does not work as planned. Finally, the teacher should be encouraged by the use of CPS technology and the benefits that can be afforded to both the teacher and the instructor and the student.

**Advantages and uses of CPS for teachers and students.** The main advantages for obtaining feedback from electronic response systems as opposed to nontechnical response systems for gathering feedback are the anonymity of responses, the capability to immediately provide formative feedback, and the ability to project students’ responses as a histogram or graph on a projection screen for everyone in the class to view (Deal, 2007; MacArthur & Jones, 2008). CPS can also save students’ responses for future analysis, interpretation, and assessment. The advantage of assigning each student his or her own clicker is that attendance and quiz score data can be recorded immediately for that student each time CPS is used (MacArthur & Jones, 2008). Keong and Pieng (2008) state, “Its prowess [CPS] lies not in the technology but in the capitalization of its ability to be used as a tool to support education processes—teaching and lecturing” (p. 485).

A variety of advantages exist when implementing CPS. Duncan (2006) states that the use of CPS is an easy way to get students to be more active. Deal (2007) reported that the use of CPS “can facilitate the process of drawing out prior knowledge, maintaining student attention, and creating opportunities for meaningful engagement” (p. 1).
As is supported by proponents of SBC, the most successful implementations of CPS occur when instructors set clear objectives and aid the achievement of those objectives through thought provoking, engaging educational tasks (Crouch & Mazur, 2001; Deal, 2007). CPS assists instructors in reaching those goals by allowing them to assess student comprehension and develop classroom tasks that allow for the application of important aspects related to classroom standards for authentic learning (Deal, 2007). Deal (2007) states that CPS implementation occurs in three formats: (a) monitoring the classroom (attendance, attention, completion of assigned readings), (b) audience-paced instruction (real-time evaluation of student comprehension), and (c) PI (question/response cycle combined with discussion and debate among students).

CPS use develops meaningful engagement among students through collaboration (Barnett, 2006), and does so even in large classes where engagement is often a major concern. Elliot (2003) mentions that CPS reduces the teacher’s workload and gives him or her the ability to move freely about the room. Using CPS allows students to see visual proof that they are not the only ones who do not understand a concept (Wood, 2004). This would certainly help build self-confidence in normally quiet students or students who are reticent to ask for help when they do not comprehend during a lesson.

CPS can be used for a variety of purposes in the classroom. Caldwell (2007) listed the uses of CPS technology as “spicing up standard lecture classes with periodic breaks, assessing student opinions or understanding related to lecture, increasing the degree of interactivity in large classrooms, conducting experiments on human responses, and managing cooperative learning activities” (p. 10). Administration and immediate scoring of summative assessment, formative assessment, and structuring of student
collaboration are other ways that CPS can be used in the classroom (MacArthur & Jones, 2008). Additional uses for CPS are assessing student preparation; ensuring accountability about required classroom readings or homework; surveying students about the pace, effectiveness, and teaching styles in lectures; polling students’ opinions or attitudes about a variety of topics/issues; probing students’ pre-existing level of understanding; completing practice problems; guiding student thinking; making lectures fun; and using questions with multiple correct answers or only partially correct answers to prompt discussion (Caldwell, 2007). CPS can be used to stimulate classroom discussions as well as to assess students’ comprehension of the curriculum in a non-threatening manner (Kaleta & Joosten, 2007).

Other uses for CPS exist that can assist educators in a SBC. Penuel et al. (2007) shared the following uses for CPS: gaining an enhanced idea of what students do and do not know, promoting student achievement, making students more cognizant of and responsible for their own learning, differentiating or individualizing instruction, improving assessment and feedback, increasing teacher productivity, saving time required for grading classroom assignments or tests, and assessing student knowledge.

**Student achievement and CPS.** According to the literature, CPS appears to be a logical choice for educators in a SBC to help promote and increase student achievement. Positive results have been obtained from studies regarding the implementation of CPS and student achievement. Kaleta and Joosten (2007) found that the use of CPS positively impacted student grades but not long-term student retention of information. Slavin and Shiell (2008) indicated that there was a positive correlation between CPS scores and class grades. A pilot study of CPS use in the 28,500 student K–12 school district in Boulder,
Colorado, resulted in increases in student achievement and student attention for students who used CPS (Manzo, 2009). Thus, the Boulder Valley School District purchased CPS for all math and science classes in its 12 middle schools and began training sessions for the teachers in those schools (Manzo, 2009). Deal (2007) stated that research for an entire course showed a 60% mean pass rate for lecture sessions in which a CPS was not used, but an 80% mean pass rate for sections using CPS. Research conducted at the University of Houston (2008) found that students’ grades increased when CPS was incorporated into lectures as opposed to their counterparts in more traditional classrooms whose grades did not increase after lectures. Research participants at Ohio State University (2008) who used CPS earned final exam scores that were about 10% higher than students who did not, the difference being an equivalent of a full letter grade.

While many studies showed an increase in student achievement, there were other studies that showed no increase. Greer and Heaney (2004) indicated that results were not conclusive that CPS actually improved student learning of required materials presented in a lecture format; however, due to the students’ perception of increased learning, the CPS technology will continue to be implemented at Penn State University, where the study was conducted. Stowell and Nelson (2007) did not find better performance on learning outcomes for CPS users as compared to flash card and hand raising audience participation methods. Nightingale et al. (2008) found a statistically significant difference in student grades between genders. One gender was the control group and the other was the treatment group who used CPS; however, the article was not clear about which gender had higher mean scores. The researchers found that overall student achievement based upon final exam scores remained about the same. Lasry and Findlay
(2007) found no difference in achievement between students who used CPS and students who used flashcards to provide student feedback.

Research supports that students perceive CPS as enhancing their learning (Albon & Jewels, 2007; Caldwell, 2007; Fies & Marshall, 2006; Jackson, 2007; Judson & Sawada, 2002; Poirier & Feldmen, 2007; Simpson & Oliver, 2007; Weiman & Perkins, 2005). Harlow et al., (n.d). found that 65% of students like using CPS, and 69% of students believe that CPS helps them learn. Dangel and Wang (2008) examined the relationship between the use of CPS and the level of student engagement and learning. Both teachers and students perceived that CPS was beneficial; however, quantifiable proof of learning could not be determined from the study. While not able to verify its benefits for learning, their research did show that CPS promotes student engagement and feedback, which are two aspects that promote learning. Students enjoy using CPS and perceive it to have a positive effect on their learning (Barnett, 2006; Harlow, 2008; Holmes et al., 2006; Jackson & Trees, 2003).

**CPS and motivation.** Research indicates that students respond positively to CPS, especially when instructors use CPS to engage and motivate students and to provide immediate feedback on their learning (Kaleta & Joosten, 2007; MacGeorge et al. 2008; Trees & Jackson, 2007). Prather and Brissenden (2009) indicated that the use of CPS technology (a) motivated students to want to answers questions correctly, (b) increased student learning, (c) positively effected test scores, (d) increased student attention, and (e) improved student interest in course content. Hall et al. (2005) found that CPS increased student motivation and engagement in large enrollment classes at the postsecondary level. Cain et al. (2009) indicated that the use of CPS technology improved student motivation
and attention as well as promoted student learning evidenced by higher course grades. Walton et al. (2008) found that students at Purdue University perceived CPS as having a positive effect on attention and classroom participation. Nonetheless, their perceptions were neutral toward CPS’s effect on motivation, utilization of instructional time, and whether or not using CPS was enjoyable. Preszler et al. (2007) performed research at New Mexico State University in order to determine the influence of CPS on student attitudes and performance. The results of this study indicated that most students had a positive impression of using CPS and believed that the technology improved their interest in the class, improved their attendance, and improved their academic performance.

Additional support for improvement in student motivation can be found in the literature. Mesa Public Schools in Arizona currently provide teacher training to their elementary teachers on using CPS to increase student motivation and increase student performance (Zahner, 2011). Manzo (2009) indicated that the use of CPS and PI increase student achievement and attention in K–12 students. Satori (2008) confirmed that CPS increased student achievement and motivation for K–12 students. Kay and Knaack (2009) found increased student motivation in 10th through 12th grade students. Bloemers (2004) found increased student motivation and student performance with sixth grade science students.

Duncan (2005) stated that student perceptions are relevant because teachers are trying to build lifelong learners, and that is only likely if the students are interested and involved in the course content. Ainsworth (n.d.) explored student perception on the use of CPS in the classroom in postsecondary classrooms in Australia. That study indicated that instructors usually make educational decisions about using technology to improve
classroom instruction and pedagogical practices without gathering student perceptions. Ainsworth further suggested that asking for and understanding student perceptions could enhance the implementation of CPS by the instructor. Research by Keong and Pieng (2008) supported requesting feedback from students about CPS in order to gather information about using this type of technology in education.

A major factor in student perception of CPS is determining whether or not it provides enjoyment of learning. A majority of students enjoy using CPS and perceive it to have a positive affect on their learning (Jackson & Trees, 2003) and would take classes in the future that use CPS technology because it is easy to use and understand (Holmes et al., 2006). This is especially true in lower-division courses as opposed to upper-division courses (Preszler et al., 2007). Barnett (2006) found that students appreciate immediate formative feedback, the interaction during lectures, peer comparisons, higher levels of involvement, exam hints, and more effective learning. Students clearly enjoy the presence of CPS in the classroom.

While research clearly indicates that there are many advantages to using CPS and that most students enjoy using CPS and perceive that this technology helps them learn, disadvantages relating to CPS in the literature have been reported and should be considered. Research indicates that common negative complaints regarding the implementation of CPS center around the cost for college students to purchase a remote control (Barnett, 2006; Greer & Heaney, 2004; May, 2007; Zhu, 2007), problems associated with technical difficulties (May, 2007; Silliman & McWilliams; 2004; Zhu, 2007), and lack of teacher skill/experience in using the technology (May, 2007), and wasted time in class due to setting up and using the technology (Barnett, 2006). In
addition, Latessa and Mouw (2005) cited potential barriers to the use of CPS as the need for more preparation time for teachers and the high cost of the technology. Elliot (2003) said that a drawback to using this technology is that traditional lectures can cover more material in the same amount of class time. Harlow et al. (2008) noticed that administrators had an increased workload when CPS was used. However, May (2007) indicated that negative comments about CPS use from teachers and students might be informative to help guide future use and eliminate the negative issues related to CPS use. In addition, even though the research points out several disadvantages regarding CPS implementation, the researcher believes that the literature can provide possible solutions to previously experienced difficulties. Appropriate preparation, technology support, and knowledge of how researched-based pedagogy complements CPS use could enhance future CPS implementation.

**CPS Pedagogies.** Several pedagogies are associated with the Constructivist and Active Learning theories and implementation of CPS technology. Penuel et al. (2007) indicated that while many different pedagogies exist and work well with CPS, all of the models, which may have slight differences, have common elements. Some of these commonalities are questioning techniques, displaying student responses via a histogram or graph, and discussing and responding to student responses. To become proficient in using these pedagogies, specialized training is necessary. These pedagogies include Question Driven Instruction (Beatty et al., 2006), PI (Crouch & Mazur, 2001), Kolb’s Experiential Learning Theory (as cited in Fies & Marshall, 2006), Technology-Enhanced Formative Assessment (Beatty & Gerace, 2009), Assessing to Learn (Dufrense & Gerace,
2004), Process-Oriented Guided-Inquiry (University of Massachusetts as cited in Fies & Marshall, 2006), and Interactive Engagement (Hake, 1998).

All of the aforementioned pedagogical theories involve active learning, questioning techniques, peer discussions, student-centered instruction, and formative assessment with frequent or immediate feedback that helps drive the instruction. These cooperative learning strategies have components known to some educators as think-pair-share. The researcher utilized a combination of overlying themes from all the theories discussed previously in this paper. However, the primary learning theory that was incorporated in this research was the active learning theory while utilizing PI.

The researcher believes that students learn more effectively and are motivated when learning is active and students can engage in discussion of subject content. The use of formative assessment through frequent, immediate feedback via the use of CPS technology allowed instructors to make immediate changes to the instruction based upon that feedback. However, when conducting research to justify the use of CPS, there must be a focus on student outcomes instead of just looking at whether or not technology was used. Distinguishing between differences in results stemming from the use of technology and the differences in results stemming from the type of methodology or teaching pedagogy utilized is a difficult task at best. Penuel et al. (2007) said that appropriate teaching strategies must be utilized in conjunction with CPS to make CPS more effective.

Elliot (2003) indicated that the implementation of CPS maintains student interest and focus while augmenting active learning and the level of interaction in a lecture setting, thus allowing teachers and students to more closely monitor the level of student understanding. Students who use CPS work cooperatively and discuss their answers to
the questions posed by teachers and then prove the accuracy of their answer to their peers. When CPS-based instruction is coupled with PI in this way, the resulting pedagogy lends itself naturally to the active learning theory.

**Peer Instruction**

Crouch and Mazur’s (2001) Constructivist instructional method known as PI, is referred to repeatedly in multiple meta-analyses of current literature about CPS (Caldwell, 2007; Fies & Marshall, 2006; Judson & Sawada, 2002; MacArthur & Jones, 2008). PI is one of the main pedagogies associated with the use of CPS (Sullivan, 2009). Another name associated with PI is interactive engagement (Deal, 2007). Eric Mazur (1997) developed the PI teaching method. PI instructors purposefully design instruction that allows students to act by teaching and learning from each other (Gilbert, Hunsaker, & Schmidt, 2007). PI also allows for any student misunderstanding of the material to be clarified immediately (Mazur, 2011). This approach to learning requires that instruction shift from the traditional teacher-led discussion of material to students either actively seeking information from their peers or confirming their knowledge with their peers (Deal, 2007). Mazur (2011) describes PI on his website as follows:

Lectures are interspersed with conceptual questions designed to expose common difficulties in understanding the material. The students are given one to two minutes to think about the question and formulate their own answers; they then spend two to three minutes discussing their answers in groups of three to four, attempting to reach consensus on the correct answer. This process forces the students to think through the arguments being developed, and enables them (as
well as the instructor) to assess their understanding of the concepts even before they leave the classroom. (para. 2)

For more than a decade in postsecondary classrooms, PI has been successfully coupled with CPS (Hake, 1998; Mazur, 1997; Pritchard, 2006) and is a proven method of increasing learning (Duncan, 2006). PI is naturally associated with active learning because as students are engaged in their own learning, they are required to become active participants in class and discuss answers with classmates (Duncan, 2005; Mazur, 2011; Sullivan, 2009). This facet of PI only enhances the impact of CPS because it increases student involvement, which can decrease the attention fade that can occur during traditional lectures (Duncan, 2005).

**Peer instruction and achievement.** Much research is available that indicates that PI increases student performance and learning (Conoley et al., 2006; Cortright, Collins, & DiCarlo, 2005; Cortright, Collins, Rodenbaugh, & DiCarlo, 2003; Crouch & Mazur, 2001; Crouch, Watkins, Fagen, & Mazur, 2007; Guiliodori, Lujan, & DiCarlo, 2006; Lasry, Mazur, & Watkins, 2008; Miller, Santana-Vega, Terrell, 2006; Perez et al., 2010; Rao, Collins, & DiCarlo, 2002; Rao & DiCarlo, 2000; Smith et al., 2009; Smith, Wood, Krauter, & Knight, 2011). However, contradictory to those results is research by Mora (2010), which indicated that PI and typical lecturing by instructors both yielded equal results in terms of student performance.

Sullivan (2009) purports that the development of effective questions when using PI is critical to positive learning outcomes and whether or not the use of CPS is an effective teaching tool. PI, when used along with CPS, often results in a higher level of questioning (Duncan, 2005; Nicol & Boyle, 2003; Sullivan, 2009). Perez et al. (2010)
found that a 14.5% increase in learning gains (changing incorrect to correct answers after peer discussion) were attributed to peer discussion; however, learning gains were increased to 19.3% when students were shown the bar graph provided with CPS technology.

**Peer instruction and motivation.** Student engagement is increased and students are more responsible for their own learning when using PI (Zhu, 2007). Research is available which indicates that instruction coupled with PI and CPS increases student motivation (Nicol & Boyle, 2003; Prather & Brissenden, 2009). Lucas (2009) found that PI with CPS enhanced student participation and comprehension. An interesting twist to research by Lucas (2009) was that he required student participants to write down the rationale for their answer in an effort to prevent students from being led astray by domineering group members. Crouch and Mazur (2001) reported differing student attitudes and opinions regarding courses taught with PI; however, very little change in student attitude about the course from the beginning to the ending of the courses were noted. Cortright, Collins, and DiCarlo (2005) indicated that their research participants using PI were “motivated, eager to learn, and had fun” (p. 109).

The rationale for PI is clear: When a student’s mind is actively relating new information to prior knowledge, lasting retention of new concepts is much more likely to occur (Duncan, 2005; Mazur, 2011). The ability to apply the new information is also a benefit of using PI techniques and enhancing learning outcomes (Duncan, 2005; Mazur, 2011). A major advantage to the PI strategy is that it can easily be implemented in any class or subject area (Mazur, 2011). When appropriately used, PI can have a positive impact on students’ learning experiences and outcomes in postsecondary level students
(Deal, 2007). For these reasons, it appears that CPS and PI are a natural match in the classroom. While CPS is not required for PI to be used, research indicates that the technology enhances and facilitates the learning process much more effectively than non-technological feedback methods (Deal, 2007). The researcher proposes that CPS along with the PI strategy has the potential to increase student achievement and motivation in middle school students as confirmed in the literature.

**Summary**

The use of CPS in classroom instruction has many positive benefits. Current literature indicates that results vary at the collegiate level as to whether or not the implementation of CPS actually affects student achievement or is only perceived to affect student achievement. As most research has been conducted on CPS at the collegiate level, a gap in the research indicates the need to study the impact of CPS when used along with an appropriate pedagogy in K–12 schools. In addition, much research has also been conducted on PI at the collegiate level; however, little research is available on PI in the K–12 setting. According to the research, an important component of student learning is student motivation. The current study sought to determine the impact of CPS-based instruction with PI on student achievement and student motivation at the middle school level. Chapter 3 presents the study’s methodology including the research design, participants, setting, instrumentation, procedures, and data analysis.
CHAPTER THREE: METHODOLOGY

NCLB (2002) requires that teachers increase student achievement so that all students will perform at grade level by 2014. As a result, teachers are held to higher standards than ever and are constantly searching for ways to improve student achievement and motivation. Classrooms that implement active learning are much more likely to produce students capable of reaching that standard (Florida State University Office of Distance Learning, 2011; Michael, 2006). Classrooms that employ CPS-based instruction along with PI could be beneficial for schools intent on achieving this goal.

Much research has been conducted in the past on CPS in education. However, most of the available research in the literature consists of studies that have investigated variables at the post secondary level in large-lecture classes or have frequently been primarily qualitative in nature. There is a very narrow scope of quantitative research regarding the effects of the implementation of technology such as CPS at the middle school level (Lively, 2010; Manzo, 2009; Penuel et al., 2007; Sartori, 2008). Most available research about CPS use in K–12 classrooms has focused on whether or not CPS was used in instruction.

The researcher for this study attempted to identify the effects of the implementation of CPS using PI on student math achievement and motivation in the middle school classroom. Other researchers (Barnett, 2006; Caldwell, 2007; Fies & Marshall, 2006; Preszler et al., 2006) have identified the need for additional research on the use of CPS and its effects in the classroom using quantitative research methodologies. Most available research about CPS did not focus on the pedagogy being used along with
the technology. Other research has failed to control variables and thus has failed to determine whether or not the effects were a result of the technology itself or of the instructional practices being used with the technology (Clark, 1983; Mayer et al, 2009).

The purpose of this research was to determine the impact of CPS-based math instruction with a specific pedagogy, PI, on eighth grade student achievement and student motivation. PI, as described more in detail in Chapter Two, was the independent variable in the treatment group in this research endeavor. Student achievement and student motivation were the dependent variables for both groups. The students received instruction based on the GPS for that grade level and subject area. Both groups received CPS-based math instruction. The instructional strategy, PI, was used in treatment group classes only. A motivation survey, the IMMS, was administered at the end of the study to all students to determine if there was a difference in student motivation between the two groups.

This chapter describes the research methodology used in the quantitative study. The chapter presents the research questions and null hypotheses, design, participants, setting, instrumentation, procedures, and data analysis for the study.

**Research Questions and Null Hypotheses**

For this study, the researcher examined the impact of CPS using PI on eighth grade math students’ academic achievement scores and motivation in one rural middle school in northeast Georgia. There were two questions that guided this research.

Research Question 1: Is there a difference in student achievement mean scores between eighth grade students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based
math instruction without PI, as measured by the expert-validated Unit 7 math posttest?

Null Hypothesis 1: There is no statistically significant difference in the mean scores on the expert-validated Unit 7 math posttest between eighth grade students who receive CPS-based math instruction with PI as opposed to those who receive CPS-based math instruction without PI, when controlling for prior knowledge.

Research Question 2: Is there a difference in motivation mean scores between eighth grade math students who receive Classroom Performance System (CPS)-based math instruction with PI as opposed to those who receive CPS-based math instruction without PI, as measured by the Instructional Materials Motivation Survey (IMMS)?

Null Hypothesis 2a: There is no statistically significant difference in the linear combination of motivation subscale mean scores between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2b: There is no statistically significant difference in the mean scores of the attention subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2c: There is no statistically significant difference in the mean scores of the relevance subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2d: There is no statistically significant difference in the mean scores of the confidence subscale between eighth grade students who receive CPS-based
math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Null Hypothesis 2e: There is no statistically significant difference in the mean scores of the satisfaction subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Design

This quantitative research investigation utilized a quasi-experimental, nonequivalent pretest-posttest only control group research design in order to determine if there was a difference in student achievement and a static control group design for student motivation between eighth grade students who received CPS-based math instruction with PI and eighth grade students who received CPS-based math instruction without PI. The researcher employed a quasi-experimental methodology since the groups were already established before the study began (Ary, 2006). While the researcher was not allowed to randomly assign the students for the study, the students were randomly placed on teams prior to the beginning of the school year. Each team was assigned an equivalent number of high, average, and low performing students. Efforts were made by administration to ensure that the demographic makeup of each team was similar. Since the control group and treatment group participants could not be randomly assigned to the groups, a non-equivalent control-group design was chosen for this study (Borg & Gall, 1989). A flip of a coin determined which of the two teams would be the control group and which would be the treatment group.
Originally, the pretest score was going to be used as the covariate. However, once the pretest was administered and scored, it was evident that the students had limited understanding of the standards to be taught as most students answered 0 or 1 out of 10 questions correctly. Because the point of a covariate is to account for initial differences between groups and because all of the students in both groups did poorly on the pretest, the researcher did not use the pretest data. To improve internal validity in the study, the researcher ran an independent sample $t$-test on the mean pretest scores for both the treatment group and the control group to determine if there was a significant difference between the instruction groups. The pretest was not controlled for since there was no significant difference between the two groups ($t(166) = -1.849, p=0.066$). Thus, the posttest only design was determined to be the best choice (Gay & Airasian, 2003). Instead, the researcher chose to use the ITBS as a covariate since the ITBS scores were readily available to the researcher. The ITBS Mathematics Total standard scores proved to be a significant predictor for the posttest. Creswell (2005) indicates that the ITBS is a well-known norm-referenced achievement test used to measure and compare students’ academic abilities.

**Participants**

This study used a convenience sample for participant selection. The participants for this study included 168 eighth grade math students from one rural northeast Georgia school. All of these students were selected based upon (a) enrollment in one of the regular or cotaught math classes instructed by one of the two teachers willing to participate in the study, (b) student willingness to participate in the study, and (c) receipt of the student’s signed parental consent form. Of the 168 student participants, 92
students were included in the treatment group and 76 students were included in the control group and were analyzed for Research Question 1. However, only 152 participants completed the survey at the end of the study and were analyzed for Research Question 2. The survey was completed by 83 students in the treatment group and by 69 students in the control group. Survey results were not obtained from 16 participants due to technical difficulties during the administration of the online survey. It was impossible for the teacher to tell which students’ survey responses were not actually submitted. To ensure that a student’s responses were not counted twice, the teacher did not have any students resubmit their responses.

Two eighth grade math teachers provided the intervention during the study. Each teacher taught five classes per day. Each class consisted of approximately 28 potential student participants.

Setting

The setting for this study was a public middle school located in a rural area of northeast Georgia. According to the Georgia Department of Education (2010a, 2010b, 2010c), the school enrollment summary data indicated the school served 527 seventh and eighth grade students at the time of the study. Approximately 67% of students were eligible for free or reduced lunch. This Title 1 school served a diverse ethnic population. Caucasian students accounted for 55.79% of the student population; Hispanic students accounted for 33.21% of the student population; Asian students accounted for 3.99% of the student population; African American students accounted for 3.80% of the population; multi-racial students accounted for 3.23% of the population. Out of this population of students, 2% received English to Second or other Language (ESOL) services, almost 9%
received gifted services, and approximately 17% met Georgia eligibility requirements for special education services. The students ranged in age from 12 to 15 years old. The student body consisted of 51.66% of male students and 49.34% were female students.

The GPS developed by the Georgia Department of Education is the curriculum that is followed in all classrooms at the school. The math teachers are required to follow a standard-based class process. The teachers expressly align the standards from the curriculum, the instruction, the assignments, the student feedback, and the assessment (Georgia Department of Education, 2011b). Students from each group for all math classes were supported with special education, ESOL, and remedial classes as appropriate or needed.

**Instrumentation**

There were three separate instruments that were utilized during the data collection phase of this study. The instruments were all designed to measure different aspects of academic performance or motivation that comprised the research data. They included the Unit 7 math posttest, the ITBS, and the IMMS.

**Unit 7 math posttest.** The Unit 7 math posttest was used to measure student achievement (See Appendix A). The teacher-created, curriculum-based measurement (CBM) focused on the content that the participating teachers presented during the unit found to be reliable at the .91 level according to Cronbach’s alpha. The GPS-based questions for the Unit 7 math exam were taken from Study Island, an online bank of questions specifically aligned and correlated to the GPS by professionals in the education and consultant industry (Magnolia Consulting, 2008, 2011; Study Island, 2011). Teacher-created tests have a long history of being utilized in educational research (Allen,
The two participating teachers administered the posttest to their students. The participants were given the entire class period (60 minutes) to complete the expert-validated, ten-question, multiple-choice test. Each correct answer was worth 10 points, for a total of 100 possible points. For the purpose of this research and to expedite the scoring of the instrument, no partial credit was given.

The Unit 7 math assessment was a teacher-made test, also referred to in this study as an expert-validated test, that was validated by one assistant principal (who was also a previous science and math teacher), one secondary curriculum director (who is also the system’s school improvement director), one high school math department teacher and department head (who is also the gifted coordinator for the school system), two eighth grade regular education math teachers, one eighth grade special education teacher, one eighth grade ESOL teacher, one eighth grade gifted teacher, and two seventh grade regular education math teachers (See Appendix B). All of the instrument reviewers are experts in the fields of mathematics and education. These experts utilized their math content area expertise, as well as knowledge of the GPS for eighth grade math curriculum, to determine the face and content validity of each instrument. They identified confusing words, unclear directions, and other problems that could negatively impact the validity of the instrument. Along with their validation duties, these experts were also asked to create a table of specifications for the ten questions on the test, which
were correlated to the eighth grade GPS for Unit 7 (See Appendix C). As recommended by Williams (2009), an Educator Qualifications for Posttest Validation Chart is included to help validate the expertise and experiences of the reviewers who helped confirm the content validity of the teacher-made test (See Appendix D).

The expert-validated test is appropriate for the purposes of this particular research study. A literature review of CPS research at the collegiate or professional level in the medical field examined 67 current peer-reviewed articles with only four of those articles including specific information about reliability and validity (Kay & LeSage, 2009). Out of these four pieces of research, only one journal article included information about both reliability and validity scores, while the other three journal articles listed validity information only. In addition, none of the extremely limited number of dissertations found regarding CPS in the K-12 setting included reliability and validity information for the pretests and posttests.

Additional support for using the scores obtained from a CBM instrument rather than a standardized test when researching technology in education comes from research by Achacosco (2003) who states, “Testing can include in-class exams or quizzes as well as standardized testing. The advantage of this method of data collection is that exams are a part of the educational system and scores are readily available” (p. 24).

**ITBS.** Scores from the 2010 administration of the ITBS (Form A, Level 13) were utilized as a covariate to statistically adjust initial group differences in math achievement as part of the ANCOVA. Salkind (2007) said that ANCOVA “basically allows you to equalize initial differences between groups” (p. 323).
The ITBS is comprised of 13 multiple choice achievement tests. However, for the purposes of this research, only data from the overall Total Math score will be utilized. The Total Math score is comprised of (a) math concepts and estimation, (b) math problem-solving and data interpretation, and (c) math computation. ITBS scores were readily available since the test is routinely given to all seventh grade students at the research site each year. The ITBS is known to be a valid and reliable instrument for the measurement of student math ability (Hoover et al., 2006). The reliability coefficient for the ITBS Math Total, which is based on the Kuder-Richardson Formula, is .93 (Hoover et al., 2006). The standard error of measurement score for the ITBS Math Total score is 7.4 (Hoover et al., 2006). This reliability coefficient indicates a satisfactory reliability (Green & Salkind, 2008).

According to Dunbar et al. (2008), the ITBS yields the following types of scores: raw score, percent correct, grade equivalent, developmental standard score, percentile rank, stanine, and normal curve equivalent. Each of these scores has advantages and disadvantages. For the purposes of this research, the researcher chose to utilize the developmental standard scores obtained from the ITBS, which was administered to the participants the previous year in the seventh grade. Dunbar et al. (2008) indicates that the developmental standard score “is a number that describes a student’s location on an achievement continuum” (p. 49). Dunbar et al. (2008) state, “The main advantage of the developmental standard score scale is that it mirrors reality better than the grade-equivalent scale” (p. 49). The average range of developmental standards scores or performance scores for seventh grade students for the ITBS is a score of 210 to 266, and the median score for seventh grade students is a score of 239 (Dunbar et al. 2008).
**IMMS.** The IMMS was used to measure student motivation. The researcher requested and received permission from the instrument’s author to use and slightly modify the IMMS to meet the needs of the research study at the middle school level (See Appendices E and F). According to Keller (2010b), the author of the instrument, the IMMS can be adapted to fit specific research needs in various situations. Keller indicates that verb tenses can be changed, and that minor wording can be changed to fit the specific situation being accessed. The survey was distributed to both the control and treatment groups at the completion of the study to determine if there was a statistically significant difference in motivation between the control and treatment groups.

The IMMS uses a Likert-type scale to gauge the responses of the participants. For each of the subscales of the IMMS, the response scale ranges from 1 to 5, with a 1 response signifying *not true*, a 2 response signifying *slightly true*, a 3 response signifying *moderately true*, a 4 response signifying *mostly true*, and a 5 response signifying *very true*. There are 36 individual items requiring response, and each of these items falls into one of four categories, which measure the motivational effect of the instructional materials. Those four categories are: attention (12 items), relevance (nine items), confidence (nine items), and satisfaction (six items). There is also a total scale score (Keller, 2010b).

The IMMS can be scored in a couple of different ways. Since the response scale ranges from 1 to 5 and the number of questions per subscale varies, the minimum score on the IMMS survey is 36, and the maximum score is 180 (Keller, 2010b). However, for the purposes of this study, the IMMS was scored using an average score on each of the four subscales rather than the sum score so that the four subscale scores could easily be
compared. Keller (2010b) recommends this method as being an “alternate and preferable scoring method” (p. 282). This scoring method converts the totals for each subscale of the IMMS into an average score ranging from 1 to 5 and makes it easier to compare participant responses on each of the subscales (Keller, 2010b). The items written in a negative format have reversed scoring (Keller, 2010b). Regardless of which way the IMMS is scored, according to Keller (2010b), “One cannot designate a given score as high or low because there are no norms for the survey. Scores obtained at one point in time, as in a pretest, can be compared with subsequent scores or with the scores obtained by people in a comparison group” (p. 283-284). In addition, since the IMMS is a “situation-specific measure, there is no expectation of a normal distribution of responses” (Keller, 2010b, p. 284). However, the researcher assumes the higher the average for each subscale, the higher the motivation is for each of the subscales for the control group and the treatment group.

The IMMS has been used in prior research in a wide variety of publications and dissertations regarding varying aspects of technology integration (Carson, 2006; Chan 2009; Chen, 2011; Cheng & Yeh, 2009; Cook et al., 2009; Door, 2006; Gabrielle, 2003; Huang et al., 2004; Huett et al., 2008; Jaemu et al., 2008; Jones, 2009; Jumanwan, 2011; Kim & Keller, 2008; Liao & Wang, 2008; Small, 2006; Yang et al., 2009). It has been widely used partly because of its excellent reliability and validity numbers. Prior reliability testing of the IMMS instrument using the Cronbach's alpha measure indicated that each of the five components (attention, relevance, confidence, satisfaction, and the total scale score) had a satisfactory reliability coefficient of .81 or higher (Keller, 2010b). Individual Cronbach’s alpha scores are as follows: attention = .89, relevance = .81,
confidence = .90, satisfaction = .92, and total scale = .96 (Keller, 2010b). Prior validity was established for the IMMS (Keller, 2010b) by various studies (Cook et al., 2009; Gabrielle, 2003; Huang, Huang, Diefes-Dux, & Imbrie, 2006; Pittenger & Doering, 2010). For the present study, the Cronbach’s alpha for attention, relevance, confidence, and satisfaction was .86, .89, .91, and .86 respectively. The overall Cronbach’s alpha score was .91.

**Procedures**

**Permissions.** Permission was obtained from the superintendent of the school system and the principal of the school to perform the research study (See Appendices G and H). An application to the Institutional Review Board (IRB) of Liberty University was submitted and approved for the research study (See Appendix I). No intervention was conducted with students and no data were collected prior to approval from the IRB. Permission for participation in the study was requested and obtained from teachers and parents of all the student participants (See Appendices J and K). The researcher informed and discussed consent with the participating teachers of the research at the beginning of the project. The teachers of each group discussed the information concerning the research and the consent forms with each of the student participants at the beginning of the project. No one was considered a participant and no data for or about any individual were utilized in this research without prior written consent from the participant and the parent. All teachers and participants were made aware that they had the option to opt out of the research at any time. Students were reassured by their teacher that participation and responses gathered during this research were not related in any way to them as individuals, the teacher’s class as a whole, or their individual course grades, but all
collected data would be used to look at student achievement and student motivation. Student participant information and consent forms for the research were provided in English and Spanish (See Appendices K, L, M, and N).

**Security and precautions.** After receiving written approval from the IRB and appropriate school personnel, the researcher executed the research plan. A list of all eighth grade students at the research site was requested and received from the school principal. Once this list was obtained, privacy, anonymity, confidentiality, and safety of the research participants were achieved through the immediate placement of pseudo labels upon participants, schools, and classrooms. Each of the potential student participant names and teacher participant names was immediately given a distinctive arbitrary number by the researcher to preserve confidentiality and the identity of all participants. Data were not collected nor included for students who did not return a signed parental consent to participate in the research or for whom no 2010 ITBS data were available.

As a teacher and department head at the research site, the researcher had been given prior password-protected access from the school principal to the school’s online data storage system, Powerschool, which then allowed the researcher to gather demographic information for all student participants. The researcher requested and received access from the school principal to obtain ITBS scores for the participants, located in each participant’s permanent school record which is kept in the school’s locked vault. When not being used by the researcher, all data obtained through the research were kept locked in a personal filing cabinet located at the home of the researcher. The key to the filing cabinet was kept in a secure location away from the filing cabinet. All
data obtained for the research will be kept for three years and will be destroyed after that time.

The researcher requested and received password-protected access from the school system’s technology director to use their online Survey Monkey account in order to develop and create a link to the online student motivation survey that was given to obtain student participants at the end of the unit of math instruction. The account was used to obtain student motivation data about CPS-based math instruction with and without the use of PI.

**Pretest administration.** Prior to treatment, the teacher of both the treatment and control groups administered the same expert-validated pretest, which covered content from Unit 7: Systems of Equations and Inequalities (as recommended by the Georgia Department of Education). To ensure consistency in grading the pretest, the students recorded their answers on a Scantron sheet, which was read and scored electronically. The teacher of both groups examined the Scantron sheets to account for any possible grading errors due to poor erasures. Upon receipt of the pretest results from the teachers of both groups, the researcher made the decision to not use that data because most students received a score of 0 through 20 on the pretest. This was problematic because the results may have resulted in bias in the interpretation of the results of the data by indicating greater gains or a more significant difference in achievement from the pretest to the posttest than what actually had been made. Thus, the researcher did not use pretest data and instead used the 2010 ITBS data as a covariate.

**Training and support.** The researcher provided a set of the same brand and model of infrared CPS response systems to each teacher participating in the research.
The researcher downloaded the appropriate version of eInstruction’s CPS software to each of the teacher’s computer in the classroom and made certain that the technology worked in conjunction with the computer and Smartboard in each teacher’s classroom. Prior to treatment, the researcher provided CPS technology training to both teachers at the same time. The researcher also provided PI training to the teacher of the treatment group only. Ongoing technical support for CPS or answers to questions related to PI were provided as needed throughout treatment.

**Treatment/intervention.** Research was conducted that allowed the researcher to monitor student achievement while implementing CPS-based math instructed using PI. However, to reduce possible bias, the researcher was not directly involved in the research process.

Both the treatment group and the control group received the same instruction from each teacher based upon the state curriculum map for the eighth grade GPS for math for Unit 7: Systems of Equations and Inequalities (as suggested by the Georgia Department of Education), which was taught over an approximately four-week period. As required by the local school system and to ensure consistency in what was taught and how it was taught and assessed, the participating math teachers planned collaboratively at least one time per week throughout the research. During their meetings, they developed and revised a common instructional framework for this unit based upon the state recommended curriculum map and framework suggested by the Georgia Department of Education for the GPS for eighth grade math. For the past three years, the teachers who implemented the research have planned together three to four times per week during a common planning time. Frequent teacher collaboration with each other and the
researcher before, during, and after the treatment ensured that both teachers were teaching the same content related to the GPS math standards for Unit 7 as closely as possible at the same time and in the same manner. Teachers for both groups assigned the same math practice problems during class and for homework. In addition, frequent collaboration allowed teachers to develop the Unit 7 expert-validated test used in this study.

The math instruction for both groups included CPS use; however, the PI instructional strategy, was only utilized in the treatment group. All students received formative feedback on a daily basis through the use of histograms and instant feedback from the use of CPS. In addition, students in both groups received feedback with traditional methods such as verbal and written commentary and grades on assignments and tests. Summative feedback was given at the end of the unit on the paper and pencil Unit 7 posttest. Teachers implemented CPS use for the duration of a four-week unit of study in both the control and treatment groups. Teachers in both groups used CPS two-three times per week during instruction, using at least five questions each time they used CPS.

Teachers collaboratively selected math questions from Study Island (2011) based upon the GPS and used these same CPS questions based upon the content to be taught each day during instruction. To ensure that the teachers used the same questions at the same time for instruction, these questions were uploaded to Study Island as customized assessments rather than allowing random math questions to pop up on the screen. For example, the purposefully chosen sets of questions were labeled for easy access by both teachers as Week 1 Lesson 1, Week 1 Lesson 2, Week 2 Lesson 1, Week 2 Lesson 2, etc.
Teachers were then able to use data obtained from the CPS questions in order to guide, drive, and change instruction during the implementation phase. The teacher of the treatment group implemented PI for the duration of the four-week unit of study. Concerns and issues that arose during the research were addressed with the teacher participants by the researcher during a common planning time during or after the school day.

CPS-based math instruction with PI was implemented with the treatment group as follows:

1. The teacher posed a math question related to the GPS for Unit 7 content using the web-based, standards-based program called Study Island and posed/projected the question on a Smartboard.
2. The students used a remote control and cast their vote and gave their answer to the question.
3. Students were encouraged to use and to engage in the PI strategy and discuss their answers with their classmates seated close to them. Students explained their answers and rationales for their answers to their peers. Students had the option to change their votes before the answer was revealed.
4. The teacher revealed the correct answer by displaying it on the Smartboard.
5. Using the CPS technology, the teacher posted a histogram, so that the teacher and the students received immediate feedback to see how their answers compared to the class results for that particular math question.
6. The teacher lead a class-wide discussion about why one answer was correct as well as why the other answers were not correct.
7. Based upon the results shown on the histogram and information gathered from the class-wide discussion, the teacher adjusted the instruction as necessary. This process was repeated until the teacher was finished asking questions. Thus, the teacher was to use data obtained from CPS questions to guide, drive, and adjust instruction based upon real-time data.

Similarly, CPS-based math instruction was implemented with the control group. The only difference was step 3, the PI strategy, was omitted.

**Unit 7 posttest administration.** After the treatment, the teacher of both groups administered the expert-validated posttest over Unit 7: Systems of Equations and Inequalities (as proposed by the Georgia Department of Education). To ensure consistency in grading on the posttest, the students recorded their answers on a Scantron sheet, which was read and scored electronically. The teacher of both groups examined the Scantron sheets to account for any possible grading errors due to poor erasures. The teacher of each group provided the scores to the researcher.

**IMMS administration.** At the end of Unit 7, the IMMS was administered online via Survey Monkey to participants in both groups in a safe, nonthreatening environment in their math classrooms. As discussed earlier, survey results were not obtained from 16 participants due to technical difficulties during the administration of the survey. It was impossible for the teacher to tell which students’ survey responses were not actually submitted. To ensure that a student’s responses were not counted twice, the teacher did not have any students resubmit their responses.

Surveys completed by the participants did not contain any individual names or other identifying data and survey results were kept anonymous. Creswell (2005)
indicated that the use of “electronic data collection in quantitative research is popular” (p. 159) and “provides an easy, quick form of data collection” (p. 159). The researcher believed that using the anonymity of an online survey format helped prevent apprehension by the participants and may have encouraged honesty (Ary, Jacobs, Razavieh, & Sorensen, 2006; Whelan, 2008). A paper version of the survey was available to anyone who chose to complete this type of survey rather than the online version. Care was taken by the teachers to make certain that students knew this was a research project specifically relating to CPS use and that their participation and responses were not detrimental to them in any way. To reduce possible bias, the researcher did not have access to the students during the survey. A copy of the online survey was included for review by the Liberty University Institutional Review Board (See Appendix O).

**Data Analysis**

This study investigated the effect of CPS-based math instruction with or without PI on the achievement and motivation of eighth grade students. Parametric tests utilized are discussed in this section.

**Analysis of student achievement data.** An analysis of covariance (ANCOVA) was conducted to see if there was a difference in the Unit 7 mean posttest scores of students who received CPS with PI and students who received CPS without PI. In order for the results of the ANCOVA to be utilized and the results considered generalized to the population of interests, several assumptions were verified using appropriate statistical analyses: reliability of the covariate, linearity, homogeneity of regression, normality, and homogeneity of variance. An ANCOVA has the ability to determine if the means between the control group and the treatment group are statistically different while
adjusting for differences in group size. This was appropriate since there were 16 more students in the treatment group than in the control group (Green & Salkind, 2008). Additionally, an ANCOVA is appropriate when groups are deemed to be nonequivalent due to lack of randomization in the selection process. A covariate, 2010 ITBS Math Total scores, was used to adjust for differences between the groups on prior math achievement. According to Gay and Airasian (2003), “Analysis of covariance adjusts scores on a dependent variable for initial differences on some other variable related to performance on the dependent” (p. 343). The means and standard deviations of the Unit 7 Posttest for the treatment group and the control group were calculated. The effect size was calculated using the Eta squared statistic and interpreted based on Cohen’s $d$ (1988).

**Analysis of student motivation data.** Data were collected from the IMMS to measure student motivation. The IMMS consists of four subscales (attention, relevance, confidence, and satisfaction) that have been determined in previous research to be correlated (Gabrielle, 2003; Keller, 2010b). Thus, a correlation matrix for each of the four subscales of the IMMS was created prior to conducting the MANOVA. Because the subscales were correlated, MANOVA was determined to be the appropriate statistical method for this research setting (Green & Salkind, 2008; Tabachnick & Fidell, 2008). The MANOVA tested whether there was a difference between the IMMS scores of students who received CPS with PI and students who received CPS without PI in terms of the linear combination of the four motivation subscales. Follow up testing was completed in order to determine which components of motivation might be significantly different between the treatment group and the control group. Since the means of two groups needed to be compared, the appropriate statistical test was determined to be a
series of independent sample \( t \)-tests (Green & Salkind, 2008; Indiana University, 2006). In order for the results of the \( t \)-tests to be utilized and generalized to the population of interests, several assumptions were verified using appropriate statistical analyses: multivariate normality, independence of units, homogeneity of variance matrices, linearity, singularity, and multicollinearity. Independent sample \( t \)-tests were then conducted to determine if the differences in the mean scores on each of the IMMS subscales for the two groups were significant or if the differences were due to sampling error.

**Summary**

This research was conducted in a public eighth grade middle school in rural northeast Georgia during one four-week unit of math study. During the course of this math unit, students in both the treatment group and the control group received CPS-based math instruction. However, only the treatment group received PI in addition to the CPS-based math instruction. At the end of the unit, student posttest scores were collected and analyzed using an ANCOVA. Additionally, at the end of the treatment all students completed a validated online survey, the IMMS, in order to measure motivation in regards to CPS-based instruction with and without PI. The IMMS scores were analyzed using a MANOVA and multiple independent sample \( t \)-tests. The results of the study are presented in the following chapter.
CHAPTER FOUR: RESULTS

The purpose of this study was to determine the impact of a PI strategy, supported by CPS technology use, on the academic achievement and motivation of eighth grade math students in a middle school in northeast Georgia. In the first part of the study, the researcher collected and analyzed posttest data for each of the participants in order to determine the impact on student achievement. In the second part of the study, the researcher collected and analyzed data from a survey instrument, the IMMS, in order to determine the impact on student motivation.

Chapter 4 is organized into four sections: (a) demographic information for the participants, (b) data analysis and results of an ANCOVA that measured the impact of CPS-based math instruction with and without PI on student, (c) data analysis and results of a MANOVA and independent t-tests that measured the impact of CPS-based math instruction with and without PI on student motivation, and (d) a summary of the results.

Demographics

The participants for this study included 168 eighth grade students from one rural northeast Georgia school. All of these students were selected based upon the following criteria: (a) enrollment in one of the regular or cotaught math classes instructed by one of the two teachers willing to participate in the study, (b) student willingness to participate in the study, and (c) receipt of the student’s signed parental consent form. Of the 168 student participants, 92 were included in the treatment group and 76 students were included in the control group. Since not all students completed the IMMS survey, demographic information for each question is presented separately.

72
Research Question 1 asked: Is there a difference in student achievement mean scores between eighth grade students who receive CPS-based math instruction with PI as opposed to those who receive CPS-based math instruction without PI, as measured by the expert-validated Unit 7 math posttest?

A total of 168 students were administered the Unit 7 posttest. Tables 2 and 3 present the demographic information for these students by instructional group.

Table 2

*Posttest: Ethnicity of Students by Instructional Group*

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Treatment Group</th>
<th></th>
<th></th>
<th>Control Group</th>
<th></th>
<th></th>
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<td>n</td>
<td>%</td>
<td>n</td>
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<tr>
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<td></td>
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<td>76</td>
<td>100.00</td>
<td>168</td>
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Table 3

Posttest: Gender of Students by Instructional Group

<table>
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<tr>
<td>Total</td>
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<td>100</td>
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</table>

Research Question 2 asked: Is there a difference in motivation mean scores between eighth grade math students who receive CPS-based math instruction with PI as opposed to those who receive CPS-based math instruction without PI, as measured by the IMMS?

One hundred fifty two students completed the IMMS survey instrument. The response rate was 90.2% (83/92) for Group A and 90.8% (69/76) for Group B. Tables 4 and 5 present the demographic information for these students by instructional group.
Table 4

**IMMS Survey: Ethnicity of Students by Instructional Group**

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Treatment Group</th>
<th>Control Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>n</td>
<td>%</td>
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<tr>
<td>Total</td>
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<td>69</td>
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</table>

Table 5

**IMMS Survey: Gender of Students by Instructional Group**

<table>
<thead>
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<th>Gender</th>
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<th>Control Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Male</td>
<td>40</td>
<td>48.20</td>
<td>30</td>
</tr>
<tr>
<td>Female</td>
<td>43</td>
<td>51.80</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>100.00</td>
<td>69</td>
</tr>
</tbody>
</table>

**Research Questions and Hypotheses**

For this study, the researcher examined the impact of PI using CPS on eighth grade math students’ academic achievement scores and student motivation in one rural middle school in northeast Georgia. There were two questions that guided this research.
Research Question 1: Is there a difference in student achievement mean scores between eighth grade students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based math instruction without PI, as measured by the expert-validated Unit 7 math posttest?

Null Hypothesis 1: There is no statistically significant difference in the mean scores on the expert-validated Unit 7 math posttest between eighth grade students who receive CPS-based math instruction with PI as opposed to those who receive CPS-based math instruction without PI, when controlling for prior knowledge.

Research Question 2: Is there a difference in motivation mean scores between eighth grade math students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based math instruction without PI, as measured by the Instructional Materials Motivation Survey (IMMS)?

Null Hypothesis 2a: There is no statistically significant difference in the linear combination of motivation subscale mean scores between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2b: There is no statistically significant difference in the mean scores of the attention subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2c: There is no statistically significant difference in the mean scores of the relevance subscale between eighth grade students who receive CPS-based
math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2d: There is no statistically significant difference in the mean scores of the confidence subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Null Hypothesis 2e: There is no statistically significant difference in the mean scores of the satisfaction subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

**Data Analysis and Results: Student Achievement**

**ANCOVA.** A one-way ANCOVA was conducted using SPSS to determine if there was a significant difference in scores on the end-of-unit test between eighth grade students who received CPS-based math instruction with PI and those who received CPS-based math instruction without PI. The PI strategy served as the independent variable and included two levels: eighth grade students who received CPS-based math instruction with PI and those who received CPS-based math instruction without PI. The dependent variable was student achievement as measured by individual scores on an expert-validated Unit 7 test. The 2010 ITBS Total Mathematic scores for each student served as the covariate.

**Assumptions.** Preliminary analyses were conducted to evaluate assumptions for the ANCOVA. Those assumptions include: (a) reliability of covariate, (b) linearity, (c) homogeneity of regression, (d) normality, and (e) homogeneity of variance.
The reliability of the covariate was assumed due to the reliability information provided by Hoover et al. (2003) in *The Iowa Tests: Guide to Research and Development*. The ITBS is known to be a valid and reliable instrument for the measurement of student math ability (Hoover et al., 2006). The reliability coefficient, which is based on the Kuder-Richardson Formula for the ITBS Math Total is .93 (Hoover et al., 2003). This reliability coefficient indicates a satisfactory reliability (Green & Salkind, 2008). The standard error of measurement score for the ITBS Math Total score is 7.4 (Hoover et al., 2003). Reliabilities reported are consistent with past tests, suggesting the assessment is reliable (Hoover et al., 2003).

The sample sizes, means, and standard deviations of the expert-validated Unit 7 posttest for Group A and Group B are listed in Table 6. Note that the design was unbalanced; there were 16 more students in Group A (CPS using PI) than in Group B (CPS without PI). The sample mean for Group A was higher than Group B, and Group B was more variable. Since the smaller sample size group was more variable, the actual Type I Error rate was slightly larger than anticipated (Montgomery, 2009).

Table 6

*Descriptive Statistics of Math Scores for Dependent Variable by Instructional Group*

<table>
<thead>
<tr>
<th>Instructional Group</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>92</td>
<td>77.92</td>
<td>15.82</td>
</tr>
<tr>
<td>Group B</td>
<td>76</td>
<td>71.22</td>
<td>21.67</td>
</tr>
<tr>
<td>Total</td>
<td>168</td>
<td>74.89</td>
<td>18.93</td>
</tr>
</tbody>
</table>
The ANCOVA was performed using SPSS. There must be a linear relationship between the covariate (ITBS Mathematics Total score) and the response (posttest) in order for the results to be generalized to the target population. The linearity relationship can be seen in Figure 1 by examining the scatterplot of Posttest vs. ITBS Math Total. Also, the Pearson correlation coefficient, $r$, of 0.34, $p < .05$ indicates a somewhat weak linear relationship between posttest and ITBS Mathematics Total score.

*Figure 1. Posttest versus ITBS mathematics total scores.*

The regression slopes must be equal for each treatment group (Green & Salkind, 2008; Montgomery, 2009). The assumption of homogeneity of regression slopes was
tested by including the interaction term in the general linear model. The interaction of instruction and ITBS Mathematics Total score yielded $F(3,164) = 1.60, p = .207$, and $\eta^2 = 0.01$. This data indicated that the interaction of instruction and ITBS Mathematics Total scores was not statistically significant at the $\alpha = 0.05$ level. The observed power is .24. Also, because the estimated effect size was only .01, it can be safely assumed that the interaction had very little effect on the response variable. Therefore, the homogeneity of regression slopes assumption was met. Green and Salkind (2008) indicate that the effect size index for ANCOVA is not strictly defined; however, the conventional upper limits are .01 for small effect size, .06 for medium effect size, and .14 for large effect size. Muijs (2011) said:

> Eta squared varies between 0 and 1, and is interpreted in the usual way; that is, 0–0.1 is a weak effect, 0.1–0.3 is a modest effect, 0.3–0.5 is a moderate effect, and $> 0.5$ is a strong effect (remember, though, that these cut-off points are just guidelines)” (p. 183).

Multiple tests were conducted to determine if the assumption of normality was met. Table 7 provides the tests of normality for the residuals for the posttest. This table indicates that there is statistically significant evidence at the 5% significance level that the residuals are not normally distributed. The appearance of a moderate departure from normality does not necessarily imply a serious violation of the assumptions. Montgomery (2009) states, “Because the F test is only slightly affected, we say that the analysis of variance is robust to the normality assumption” (p. 77). The model requires independent observations. Since the posttest is a test with attention given to proctoring and proper scoring, it is safe to assume that scores are independent.
Table 7

Tests of Normality for the Posttest

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov(^a)</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>Residual for Posttest</td>
<td>.08</td>
<td>168</td>
</tr>
</tbody>
</table>

\(^a\)Lilliefors Significance Correction.

In addition, the data must also meet the assumption of homogeneity of variance, meaning that the distribution of the dependent variable for one of the groups being compared must have constant variance across factor levels. Levene’s Test of Equality of Error Variances shows statistical evidence of the homogeneity of variances. Results indicated that \(F(1,166) = 6.38, p = .013\); therefore, equal variances cannot be assumed. This test of significance indicates there is sufficient statistical evidence that the error variances are unequal. Variance-stabilizing transformations were performed to correct the inconstant error variances (Montgomery, 2009). The square root, log, reciprocal square root, and reciprocal transformations were applied with no improvement in the equality of variance (Montgomery, 2009). This increases the chance of a Type I Error, thus a significant difference between groups may be found when there is not a statistically significant difference in reality (Green & Salkind, 2008).

The scatterplot matrix in Figure 2 shows that the variances of the residuals versus predicted values are not equal. For example, observe how the residuals for posttest versus predicted posttest in Figure 2 are more condensed vertically for Group B (CPS without PI) than Group A (PI with CPS).
Figure 2. Residuals versus predicted values by instruction.

**ANCOVA results.** Tables 6 and 7 and plots in Figures 1 and 2 indicate that the modeling requirements of ANCOVA have been met. The general linear model was analyzed with only the main effects, instruction and ITBS Mathematics Total score, without the interaction term. The covariate ITBS Mathematics Total proved to be a significant predictor for the posttest with $F(1, 165) = 24.46, p < 0.001, \eta^2 = 0.13$. This indicates that the inclusion of the ITBS Mathematics Total score explained 12.9% of the variation in posttest scores. The experimental factor of instruction is also a significant predictor for posttest with $F(2, 165) = 7.6, p = .007, \eta^2 = 0.044$. This result indicates that instruction, which utilized PI with CPS, produced a statistically significant difference in posttest scores. However, only 4.4% of the variation in posttest scores is explained by instruction. This observed power is an example of post-hoc power, which has its limitations. The observed power of 0.78 indicates that if the parameters are as expected, the researcher would reject the null hypothesis 78% of the time when this experiment is conducted.
The parameter estimates for the ITBS Mathematics Total for the instruction for Group A is 7.49, with a 95% confidence interval (2.12, 12.85). This indicates that, on average, a student in Group A scored 7.49 points higher on the expert-validated Unit 7 posttest than a student in Group B when accounting for the influence of ITBS Mathematics Total scores.

Table 8 displays the adjusted means for posttest scores when using the ITBS Mathematics Total score of 223.10 to evaluate the model. From this perspective, it is easier to see the difference in means for each instructional group. There is a 7.6 point difference in adjusted means, which shows a greater disparity than the 6.7 point difference in actual mean posttest scores between classes.

Table 8
Adjusted Means and 95% Confidence Intervals for Unit 7 Math Posttest Scores

<table>
<thead>
<tr>
<th>Instructional Group</th>
<th>$M$</th>
<th>$SE$</th>
<th>$LL$</th>
<th>$UL$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>78.28</td>
<td>1.83</td>
<td>74.68</td>
<td>81.88</td>
</tr>
<tr>
<td>Group B</td>
<td>70.79</td>
<td>2.01</td>
<td>66.83</td>
<td>74.76</td>
</tr>
</tbody>
</table>

Note. CI = confidence interval; $LL$ = lower limit; $UL$ = upper limit.

After interpreting the results of the ANCOVA, the null hypothesis of no difference in the mean math posttest scores between instructional groups was rejected based upon statistically significant results.

**Data Analysis and Results: Student Motivation**

**MANOVA.** The purpose of this analysis was to determine the effect of the type of instruction (CPS with the use of PI and CPS without using PI) on student motivation,
as measured by four response subscales: attention, relevance, confidence, and satisfaction. A MANOVA is a multivariate procedure that simultaneously examines the group differences between correlated dependent variables. Since the four subscales of the IMMS are known to be correlated in previous research (Gabrielle, 2003; Keller, 2010b), a correlation matrix for each of the four subscales of the IMMS was created prior to conducting the MANOVA. Since the data were multivariate and univariate normal and the covariance matrices were equal, a MANOVA was appropriate (Muijs, 2011).

The Pearson Correlation Matrix is depicted in Table 9.

Table 9

Pearson’s Correlation Matrix for IMMS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Attention</th>
<th>Relevance</th>
<th>Confidence</th>
<th>Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>–</td>
<td>.76*</td>
<td>.69*</td>
<td>.84*</td>
</tr>
<tr>
<td>Relevance</td>
<td>–</td>
<td>–</td>
<td>.56*</td>
<td>.81*</td>
</tr>
<tr>
<td>Confidence</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>.68*</td>
</tr>
</tbody>
</table>

*Note. *p < .05.

The correlation matrix indicated that all correlations for each of the four subscales of the IMMS were significant at the 0.01 level indicating that a MANOVA was an appropriate test to use (Green & Salkind, 2008; Huberty & Olejnik, 2006; Tabachnick & Fidell, 2007).

The pooled means and standard deviations for the four subscales of the IMMS (attention, relevance, confidence, and satisfaction) were $M = 3.00$ ($SD = .77$), $M = 3.20$ ($SD = .73$), $M = 3.18$ ($SD = .81$), and $M = 3.01$ ($SD = 1.00$), respectively.
Table 10 provides the descriptive statistics for the two levels of instruction. The data in this table indicates that the group means for each variable were similar, but the values were generally larger for Instruction Group A.

Table 10

*Descriptive Statistics for the IMMS Subscales by Instructional Group*

<table>
<thead>
<tr>
<th>IMMS Subscales</th>
<th>Group A Treatment ( (n = 82) )</th>
<th>Group B Control ( (n = 69) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )  ( SD )</td>
<td>( M )  ( SD )</td>
</tr>
<tr>
<td>Attention</td>
<td>3.16  0.82</td>
<td>2.82  2.82</td>
</tr>
<tr>
<td>Relevance</td>
<td>3.35  0.75</td>
<td>3.00  3.00</td>
</tr>
<tr>
<td>Confidence</td>
<td>3.28  0.81</td>
<td>3.06  3.06</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>3.17  0.995</td>
<td>2.82  2.82</td>
</tr>
</tbody>
</table>

*Assumptions.* Preliminary assumption testing was conducted for the MANOVA to evaluate the assumptions of multivariate normality, independence of units, homogeneity of variance matrices, linearity, singularity, and multicollinearity, which were all satisfactory for each of the four subscales of the IMMS.

In order for the results of the IMMS to be generalized to the population of interest, seven modeling assumptions had to be verified prior to conducting the MANOVA. The first assumption for MANOVA is that all numbers in each cell are larger than the number of dependent variables. Both instruction groups A and B had more subjects in each group than the number of dependent variables. Each instruction group had sample sizes greater than 30, so the Central Limit Theorem applied; therefore, the assumption of univariate normality was met (Schmuller, 2009; Wrench, Thomas-
Maddox, Richmond, & McCroskey, 2008). Equivalent group sizes are best, but not vital. Learning Domain (2011) states, “Generally, if the cell size [group size] is greater than 30, assumptions of normality and equal variances are of less concern” (para. 1).

The second assumption for MANOVA is independence of units. The researcher attempted to ensure that the assumption of independence was met by providing training on how to proctor the IMMS survey to the teachers in charge of each instruction group. Classroom control and a quiet environment were maintained during the administration of the online survey in all classes. The teacher in charge of each group circulated among the students as they completed the survey and provided uniform directions. Within the class and across classes, students did not talk or discuss the survey questions while taking the survey. Thus, the researcher assumed that each participant’s scores on the IMMS variables were independent from scores of all the other participants.

The third assumption for MANOVA is linearity. There should be a linear relationship between any two dependent variables. Review of the matrix of scatterplots revealed that this assumption was met since each group had equitable, balanced distributions (Tabachnich & Fidell, 2008). See Figure 3 to view the linear relationship between each pair of outcomes.
The fourth and fifth assumptions are singularity and multicollinearity. Results of the evaluation for singularity and multicollinearity were satisfactory. None of the variables were redundant since none are a combination of two or more of the other variables (Tabachnick & Fidell, 2008). Since none of the variables were considered very highly correlated, i.e., .90 and above, multicollinearity does not exist (Tabachnick & Fidell, 2008). Table 10 shows the correlations for the variables.

While not an actual assumption for a MANOVA, the presence of outliers should be considered. After a careful review and comparison of the Mahalanobis distance score with the critical values for each case, no univariate or multivariate outliers were found.

The sixth assumption for MANOVA is multivariate normality. Table 11 provides a within-class summary of Mardia’s skewness and kurtosis (Mardia, 1970). All results show insignificant $p$ values for both classes. The assumption of multivariate normality was met.
Table 11

*Summary of Within-Class Tests for Multivariate Normality*

<table>
<thead>
<tr>
<th>Instructional Group</th>
<th>Statistic</th>
<th>n</th>
<th>Estimate</th>
<th>κ</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Mardia's Skewness</td>
<td>83</td>
<td>1.25</td>
<td>17.28</td>
<td>.635</td>
</tr>
<tr>
<td>Group A</td>
<td>Mardia's Kurtosis</td>
<td>83</td>
<td>23.12</td>
<td>-0.58</td>
<td>.562</td>
</tr>
<tr>
<td>Group B</td>
<td>Mardia's Skewness</td>
<td>69</td>
<td>2.20</td>
<td>25.31</td>
<td>.190</td>
</tr>
<tr>
<td>Group B</td>
<td>Mardia's Kurtosis</td>
<td>69</td>
<td>24.68</td>
<td>0.41</td>
<td>.684</td>
</tr>
</tbody>
</table>

The final assumption test for MANOVA is homogeneity of variance-covariance. The assumption of homogeneity of variance-covariance was not tenable based on the results of the Box’s test, $M = 26.82$, $F(2.60, 26.04) = 10.996$, $p = .004$. This provides evidence that the population covariance matrices are not equal. However, Tabachnick & Fidell (2007) indicate that if the significance value is larger than .001, then the assumption has not been violated. To be entirely confident in the analysis, Yao’s Test was performed using a macro. Huberty and Olejnik (2006) state, “If the assumption of equal covariance matrices is not met and the researcher doubts the validity of the Hotelling $T^2$ test, a procedure analogous may be used [Yao’s Test]” (p. 43).

This indicates that the classes have significantly different mean values when considering all components of motivation simultaneously. Since there are only two populations being compared, all of the multivariate effect size indices give the same value.

This indicates that the classes have significantly different mean values when considering all components of motivation simultaneously.
Levene’s test of equality of error variances was completed (see Table 12). Based on the results of Levene’s Test of Equality of Error Variances, the researcher found no statistically significant evidence that the variances across instruction groups were unequal.

Table 12

*Levene’s Test of Equality of Error Variances*°

<table>
<thead>
<tr>
<th>Variable</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>2.603</td>
<td>1</td>
<td>150</td>
<td>.109</td>
</tr>
<tr>
<td>Relevance</td>
<td>0.879</td>
<td>1</td>
<td>150</td>
<td>.350</td>
</tr>
<tr>
<td>Confidence</td>
<td>0.050</td>
<td>1</td>
<td>150</td>
<td>.823</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.050</td>
<td>1</td>
<td>150</td>
<td>.824</td>
</tr>
</tbody>
</table>

*Note.* Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
°Design: Intercept + Instruction

**MANOVA results.** Results for the MANOVA yielded statistically significant differences between the two groups based on the combined dependent variables, Pillai’s Trace = .07, $F(4, 147) = 2.59, p = .039$, partial $\eta^2 = .04$. Based upon these results, evidence was sufficient to reject null hypothesis 2a. Eighth grade math students who received CPS-based math instruction using PI had motivation scores that were significantly higher than eighth grade math students who received CPS-based math instruction without using PI in terms of the linear combination of attention, relevance, confidence, and satisfaction.

Since MANOVA met all the assumptions and the results were found to be statistically significant for all four subscales of the IMMS, an independent samples *t*-test
was conducted as a follow-up analysis to examine the components of motivation separately.

**Independent t-tests.** Since a significant result on the multivariate test of significance was obtained, further analyses on the dependent variables were conducted in the form of *t* tests. Using the Bonferroni method, each independent *t* test was tested at a .0125 alpha level. This controlled for the experiment-wise Type I Error rate. While some researchers purport that ANOVA is more robust than a *t*-test (Zhang, 2009), a review of the literature indicates that a *t*-test can be just as robust as the ANOVA (Zijlstra, 2004). In fact, a *t*-test is considered to be a special case of ANOVA (Indiana University, 2006). Statistically, a *t*-test yields the same results as an ANOVA when there are two levels of the grouping variable (McDonald, 2009; Wu, 2009).

**T-test results.** The researcher conducted a *t*-test for each subscale of the IMMS (attention, relevance, confidence, and satisfaction). Results showed insignificant differences for confidence, \( t(150) = 1.73, p = .085, d = 0.28, \) observed power = 0.21; and for satisfaction \( t(150) = 2.21, p = .029, d = 0.36, \) observed power = 0.38 between the group that received CPS-based math instruction with PI and the group that received CPS-based math instruction without PI. Results showed significant differences between the groups for attention, \( t(150) = 2.72, p = .007, d = 0.44, \) observed power = 0.57; and for relevance \( t(150) = 3.03, p = .003, d = 0.49, \) observed power = 0.69. For the attention component, the observed power is 0.57. Therefore, when this experiment was conducted, there was a 57% chance of obtaining a statistically significant result when the null hypothesis was actually false. For the relevance component, the observed power is 0.69.
Therefore, when this experiment was conducted, there was a 69% chance of obtaining a statistically significant result when the null hypothesis was actually false.

An examination of the mean scores in Table 11 showed that students who received PI had slightly higher mean scores for both confidence and satisfaction. Based on Cohen’s d, .2 is a small effect, .5 is a medium effect, and .8 is a large effect. The effect size was medium for both attention and relevance. Based on the results, there was insufficient evidence to reject the following null hypotheses: (a) There is no statistically significant difference in confidence between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS, and (b) there is no statistically significant difference in satisfaction between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS. Sufficient evidence was found to reject the following null hypotheses: (a) There is no statistically significant difference in attention between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS, and (b) there is no statistically significant difference in relevance between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Summary

Through the use of this quasi-experimental, posttest, nonequivalent groups design research study, the researcher was able to determine if there was a statistical difference between student achievement scores and the levels of student motivation for eighth grade
students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI. The first consideration was the descriptive statistics for the data.

Statistical analyses were performed. An ANCOVA was performed using posttest scores and the 2010 ITBS Mathematics Total scores as a covariate. A MANOVA and independent t-test were also conducted. The use of PI with CPS-based math instruction resulted in a statistically significant difference in motivation for two out of the four subscales on the IMMS. The null hypotheses were rejected for the attention and relevance subscales on the IMMS, but not for the confidence and satisfaction subscales on the survey.

By determining if there was a statistically significant difference, the researcher was able to decide if using a specific instructional strategy with CPS technology is justified due to its impact on student achievement scores and student motivation. Students who received CPS-based math instruction with PI demonstrated a statistically significant increase in scores on an expert-validated unit posttest. Students who received CPS-based math instruction with PI had statistically higher means for student motivation in two out of four subscales, as measured by the IMMS. Chapter 5 will discuss the implications of using PI with CPS based upon the results set forth in this chapter.
CHAPTER FIVE: SUMMARY AND DISCUSSION

The previous chapter presented data analysis utilizing an ANCOVA, a one-way MANOVA, and multiple independent sample t-tests to compare the differences between student achievement scores and motivation of eighth grade students who received CPS-based math instruction with PI compared to eighth grade students who received CPS-based math instruction without PI in one rural northeast Georgia middle school. Descriptive statistics and summaries were also presented.

The purpose of this chapter is to review the findings of this study and discuss them. This chapter is divided into the following sections: summary of the study, statement of the problem, summary of the findings, discussion of the findings and the implications in light of the relevant literature, study limitations, recommendations for future research, and conclusion.

Restatement of the Problem

NCLB (2002) mandates that all students make gains in achievement and that all students will perform at or above grade level by 2014. At the same time, students expect classrooms to be interactive and engaging. Administrators and teachers are charged with providing instruction and engaging learners in a learning environment that produces high levels of academic achievement. CPS may be one of the tools that help accomplish this goal. Over the past 30 years, CPS has been used as a technological tool for increasing student engagement in postsecondary classrooms, but limited research has been conducted to measure its effectiveness in K–12 classrooms (Lively, 2010; Musselman, 2008; Rigdon, 2010; Sartori, 2008; Shirley, 2009). Thus, the problem
addressed in this study was to determine if CPS, when used in conjunction with PI, could be a viable solution for increasing both academic achievement and student motivation in K–12 classrooms. A review of the literature affirmed conflicting results about the effectiveness of the implementation of CPS technology in increasing student achievement and student motivation.

Educators have long been charged with helping all students be successful in school. Due to high stakes testing, educators are held even more accountable for making certain that student achievement is a top priority. Integrating technology appropriately into the classroom along with specific methodology is one way in which student achievement scores may be increased. Students have grown up in a technologically advanced world and have become more technologically savvy due to a flood of technological gadgets on the market and in their home. Therefore, educators must be aware of current strategies and technological tools that not only help engage and motivate students to learn but actually result in increased student achievement. Students have become bored with the traditional ways of learning and often lose interest and motivation unless the teacher incorporates new instructional methods in order to increase student motivation as well as student achievement, which is always the teacher’s ultimate goal (Chen, 2010).

This study focused on eighth grade students in one rural, public middle school in northeast Georgia who were taught in a regular or cotaught math class. Both the treatment and the control group included regular education students as well as students with disabilities. Because of NCLB mandates, educators must raise academic achievement each year until the year 2014 when 100% of students are expected to be on
grade level and all schools are expected to make AYP (NCLB, 2002). Classrooms that implement active learning may be more likely to produce students capable of reaching that standard (Florida State University Office of Distance Learning, 2011; Michael, 2006). Utilizing CPS-based instruction along with PI could be extremely successful for schools intent on achieving AYP.

**Restatement of the Research Questions and Null Hypotheses**

This study focused on answering two research questions. Two research questions guided the researcher during this study:

**Research Question 1:** Is there a difference in student achievement mean scores between eighth grade students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based math instruction without PI, as measured by the expert-validated Unit 7 math posttest?

**Null Hypothesis 1:** There is no statistically significant difference in the mean scores on the expert-validated Unit 7 math posttest between eighth grade students who receive CPS-based math instruction with PI as opposed to those who receive CPS-based math instruction without PI, when controlling for prior knowledge.

**Research Question 2:** Is there a difference in motivation mean scores between eighth grade math students who receive Classroom Performance System (CPS)-based math instruction with Peer Instruction (PI) as opposed to those who receive CPS-based math instruction without PI, as measured by the Instructional Materials Motivation Survey (IMMS)?

**Null Hypothesis 2a:** There is no statistically significant difference in the linear combination of motivation subscale mean scores between eighth grade students who
receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2b: There is no statistically significant difference in the mean scores of the attention subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2c: There is no statistically significant difference in the mean scores of the relevance subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based math instruction without PI, as measured by the IMMS.

Null Hypothesis 2d: There is no statistically significant difference in the mean scores of the confidence subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Null Hypothesis 2e: There is no statistically significant difference in the mean scores of the satisfaction subscale between eighth grade students who receive CPS-based math instruction with PI and eighth grade students who receive CPS-based instruction without PI, as measured by the IMMS.

Summary of the Results

Research question 1: student achievement. The primary purpose of this quasi-experimental non-equivalent control group study was to examine the impact of CPS-based math instruction on student achievement with and without PI. The researcher studied two groups (a control group and a treatment group) of eighth grade math students
in a rural middle school during the spring of 2011. While both groups of students used CPS, only the treatment group used the PI instructional strategy along with the use of CPS. An expert-validated posttest was administered to 168 participants. The treatment group consisted of 92 participants, and the control group consisted of 76 students.

The results of the ANCOVA showed a statistically significant difference in the student achievement scores of the two groups. Students who received CPS-based math instruction with PI had a mean score of 6.70 points higher on the expert-validated math posttest before accounting for the covariate, 2010 ITBS scores. When accounting for and adjusting the mean scores based upon the covariate, the adjusted mean score for the posttest for the treatment group was 7.60 points higher than the control group. The results of the ANCOVA indicated that the use of CPS-based math instruction along with a PI instructional strategy does contribute to an increase in student achievement. Based upon results from the analyses for Research Question 1, Null Hypothesis 1 was rejected because there was a statistically significant difference in the academic achievement scores of the treatment group.

**Research question 2: student motivation.** The secondary purpose of this static control group study was to examine the impact of CPS-based math instruction with and without PI on the student motivation of eighth grade students. The response rate for completing the online survey was 90.2% (83/92) for treatment group and 90.8% (69/76) for the control group. A MANOVA and multiple independent t-tests were used to examine the scores for each group for the validated survey instrument, IMMS. The results of the MANOVA indicated that students who received CPS-based math instruction with PI had higher mean scores for motivation when the linear combination of
all four subscales of the IMMS survey were considered simultaneously. Since a significant result on the multivariate test of significance was achieved, independent sample \(t\)-tests were performed for each subscale of the IMMS. Using the Bonferroni method, each independent \(t\)-test was tested at a .0125 alpha level to control for the experiment-wise Type I error rate. The results of multiple \(t\)-tests indicated a statistically significant difference in the student motivation scores of the treatment group in two out of four of the subscales (attention and relevance). When the Bonferroni method was not used to control for the experiment-wise Type I error rate, the results of multiple tests indicated a statistically significant difference in the student motivation scores of the treatment group in three out of four of the subscales (attention, relevance, and satisfaction). The results of the MANOVA and multiple independent \(t\)-tests indicated that the use of CPS-based math instruction along with a PI instructional strategy does contribute to an increase in student motivation but only for attention and relevance.

Based upon the analysis of data for Research Question 2 Null Hypotheses 2a, 2b, and 2c were rejected. Null Hypotheses 2d and 2e were not rejected. While there was a difference in the third and fourth subscales of the IMMS relating to confidence and satisfaction for the two groups, the difference was not statistically significant.

**Discussion of the Results**

**Research question 1: student achievement.** The findings of this study support other research, which confirms that PI increases student performance and learning at the postsecondary level (Conoley et al., 2006; Cortright et al., 2003; Cortright et al., 2005; Crouch & Mazur, 2001; Crouch et al., 2007; Guiliodori et al., 2006; Lasry et al., 2008; Miller et al., 2006; Rao et al., 2002; Rao & DiCarlo, 2000). The findings of this study are
contradictory to research by Mora (2010), which indicated that PI and typical lecturing by instructors both yielded equal results for student performance.

The findings of this study support research that indicated students at the postsecondary level enjoy using CPS and perceive that CPS enhanced their learning (Albon & Jewels, 2007; Barnett, 2006; Caldwell, 2007; Fies & Marshall, 2006; Harlow et al., 2008; Holmes et al., 2006; Jackson, 2007; Judson & Sawada, 2002; Poirier & Feldman, 2007; Simpson & Oliver, 2007; Weiman & Perkins, 2005). Similar to the results for this study, the use of CPS at the postsecondary resulted in higher scores in student achievement such as overall student course grades, and student test scores (Deal, 2007; Kaleta & Joosten, 2007, Ohio State University, 2008; Slavin & Shiell, 2008; Kaleta & Joosten, 2007; University of Houston, 2008). Contrary to the results of this research, other researchers’ results were not conclusive or yield mixed results that CPS actually improved student achievement at the postsecondary level (Dangel & Wang, 2008; Greer & Heaney, 2004; Lasry & Findlay, 2007; MacArthur & Jones, 2008; Nightingale et al., 2008; Stowell & Nelson, 2007).

A review of the literature indicated evidence to support that PI as well as the use of CPS increases student achievement. Based upon the review of the literature and the current study’s findings, there is an implication that administrators and teachers who want to improve student achievement and ultimately make certain that students are able to pass high-stakes standardized tests at the end of the year and meet AYP goals as mandated by NCLB (2002) should encourage teachers to incorporate CPS into instruction along with a pedagogy such as PI (Mazur, 2011). The findings of this study support that use of CPS-based instruction with PI does increase student achievement.
The current study further contributes to the field of existing research by adding a quantitative study on the impact of CPS-based instruction when used with the PI instructional strategy on math student achievement in the K–12 setting. Most available research on this topic related to CPS was conducted at the postsecondary level or did not include PI as an instructional strategy. Most available studies in the K–12 setting have examined the perceptions of teachers or students about CPS use or compared the achievement of students in classrooms that use CPS with those that do not use CPS.

**Research question 2: student motivation.** The findings of this study support other research, which confirms that that CPS or PI positively affect student motivation. Zhu (2007) indicated that student engagement is increased and students are more responsible for their own learning when using PI. Students perceive that motivation is increased through the use of CPS (Judson & Sawada, 2006). Horowitz (1988) reported that attention increases with the use of CPS technology. Students believe CPS is fun and that teachers can turn a typical classroom lecture into an engaging learning experience, thus providing the opportunity for student motivation to be increased (Albon & Jewels, 2007; Hoffman & Goodwin, 2006). Duncan (2005) indicated that student attitudes are positive when CPS is used with peer discussions.

The findings of this study indicate that the students in the treatment group who received CPS-based instruction with PI positively impacted the attention and relevance components of student motivation. However, the confidence and satisfaction components were not found to be statistically significant, which was surprising to the researcher since current and previous research indicate that the four components of the IMMS are correlated. As suggested by Hudson et al. (2010), the researcher believed that (a)
feedback from peer discussions and the instructor to clarify misunderstandings, and (b) the ability to compare results with their peers without penalty would have positively affected the score on the confidence component. In addition, Hudson et al. (2010) suggest that (a) the realization that recently acquired knowledge can contribute to success on current and future classroom performance, and (b) the ability to discuss responses to questions related to course content should give students a sense of control over their learning and positively affect the satisfaction component.

It is possible for educators to identify motivational requirements and to design motivational enhancements as described by Keller (2010a) that will improve student performance and student motivation (Keller & Suzuki, 2004). Using Keller’s ARCS model can help educators purposefully design instruction that will meet the need to increase student motivation (Keller & Suzuki, 2004), which may ultimately increase student achievement. The researcher did not use Keller’s instructional design in this study. Thus, the researcher is led to believe that if the study had been designed with the addition of specific instructional strategies that the results for the confidence and satisfaction components of the IMMS might have yielded different results. Keller (1999) made the following suggestion for promoting confidence: Increase individual praise to students so that their success is attributed to their own hard work and effort rather than chance. Had Keller’s instructional strategy been designed into this study, then the confidence score could have been statistically significant for students who received CPS-based instruction with PI. Keller (1999) also stated that confidence can be built into the instructional design by making the objectives clear and by providing examples of acceptable achievements. Thus, it is a surprise to the researcher that the confidence
scores for students who received CPS-based instruction with PI were not higher because students were made aware of course objectives and the course objectives were often referenced and examples of quality work were often provided as required in a SBC. Additionally, Keller (1987) purports that confidence can be improved by increasing a student’s belief in their personal competence by providing multiple varied and challenging opportunities for increasing the likelihood of learning success.

Keller (1999) made the follow suggestions for promotion satisfaction: Provide tangible rewards such as certificates, special privileges, stickers, school supplies, etc. Had Keller’s instructional strategies been designed into this study, then the satisfaction score could have been statistically significantly for students who received CPS-based instruction with PI. In addition, Keller (1999) suggested that the satisfaction component can be positively affected when students feel that the amount of work expected of them is fair and appropriate.

Additionally, after the study and the survey data relating to motivation had been analyzed, the researcher discussed possible reasons that the confidence and satisfaction components of the PI group were not found to be statistically significant for the group who received CPS-based instruction with PI. The teacher of the PI group felt it was important to point out to the researcher that the complexity of the math material in Unit 7 may have affected the outcome of the student responses to the survey. Prior to the answering the clicker questions, the students had to read each question, write out a mathematical equation, graph the equation, and find the solution to the equation. Teachers stated that with the complexity and level of higher-order thinking skills required for the math questions in this particular unit, that students often felt rushed to determine
The teacher of the PI group also indicated that the questions used with CPS were limited in variety and complexity compared to the problems practiced in class when not using CPS.

**Implications**

Administrators and educators are constantly looking for ways to improve student achievement and motivation. The current study provides supporting evidence that administrators should consider and encourage the continued use of CPS technology along with PI in the classroom as one way to increase student achievement and student motivation. However, based upon current economic hardships across the nation, administrators and teachers should use caution when making recommendations for the purchase of new CPS technology. Administrators could apply for grants to purchase CPS technology or research CPS companies who allow schools to borrow CPS equipment. Administrators could also check with other schools within their system that are not utilizing the CPS technology that they have already purchased. In situations where CPS technology is not available, educators could still implement the PI strategy with students.

The current study analyzed student achievement scores and student motivation in math based on the use of CPS along with a specific instructional strategy, PI. The study provides administrators and educators quantitative evidence to support or reject the suggestion that CPS equipment be used in conjunction with PI in the K–12 classroom so that a positive, active learning environment can be maintained. Keller (1984) theorized in the ARCS model of motivation design that instruction can be purposefully and systematically designed and implemented to stimulate increased student motivation and ultimately, increased student achievement. Keller (2004) indicated that if all four
components of the ARCS model are met, then “students are likely to not only have a high level of motivation to learn in the immediate setting, but to also have a continuing motivation to learn” (p. 232). Keller’s (1999) model has been used successfully and validated by many researchers (Carson, 2006; Chan, 2009; Chen, 2011; Cheng & Yeh, 2009; Cook, Beckman, Thomas, & Thompson, 2009; Dunn, Rockinson-Szapkiw, Holder, & Hodgson, 2010; Gabrielle, 2003; Huang et al., 2004; Huett, Kalinowski, Moller, & Huett, 2008; Jaemu, Kim, & Lee, 2008; Jumanwan, 2011; Keller, 1997; Kim & Keller, 2008; Keller & Suzuki, 2004; Liao & Wang, 2008; Means, Jonassen & Dwyer, 1997; Rockinson-Szapkiw, Holder, & Dunn, 2011; Small, 2006; Small & Gluck, 1994; Visser & Keller, 1990; Yang, Tsai, Chung, & Wu, 2009) and teachers in a wide variety of instructional environments to acquire and maintain student attention, to help students understand the personal relevance of material so that they can engage in authentic learning experiences, to help build and maintain student confidence, and to ascertain student satisfaction.

In terms of the current study, students who used CPS with PI had statistically significant improved academic achievement, were more attentive, and felt that the material was more relevant to them. While confidence and satisfaction scores for the students who received CPS-based math instruction with PI were not considered statistically significant, mean scores for those two components were higher than those for the group who did not use PI. Using Keller’s (1987, 1999) additional instructional strategies, the confidence and satisfaction components of motivation for CPS-based instruction could possibly have been increased.
This current study is unique from other relevant studies on this topic in that a two-part design pre-test-posttest non-equivalent design and static control group was implemented to determine the effect of the independent variable (PI) on the dependent variables (student achievement and student motivation) while controlling for prior knowledge. The field of existing literature was expanded by this study because it provided additional evidence that a statistically significant difference exists in student achievement and student motivation, in the areas of attention and relevance, when the PI instructional strategy is added to the use of CPS at the K–12 level.

Research supports that CPS and PI increase student achievement and motivation. Mesa Public Schools in Arizona currently provide teacher training to their elementary teachers on how to utilize CPS to increase student motivation and increase student performance (Zahner, 2011). Manzo (2009) indicated that the use of CPS in well planned lessons resulted in increases in student achievement and attention. Satori (2008) confirmed that CPS increased student achievement and motivation for K–12 students. The use of CPS increased student motivation in tenth through twelfth grade students (Kay & Knaack, 2009). Bloemers (2004) stated that CPS increased student motivation and student performance with sixth grade science students (Bloemers, 2004). Preszler et al. (2006) indicated that CPS improved students’ performance, increased interest in their courses, and motivated them to attend more lectures.

Limitations

Several limitations of this study were identified. First, the participants in this study were not randomly assigned to the groups, as teachers and classes were already intact once the research began. While the researcher was not allowed to randomly select
the students for the study, school administrators randomly placed the students into classrooms on each of the two teams prior to the beginning of the school year. Each team was assigned an equivalent number of high, average, and low performing students. Students with disabilities and students with English as a second language were placed in groups according to their individual needs. Efforts were made by administration to ensure that the demographic makeup of each team was similar.

There was also a difference in the size of the groups. The researcher used ANCOVA to minimize the difference between group sizes. A flip of a coin determined the assignment of teams to either the control group or the treatment group.

The teachers that were recruited to assist with the research study were volunteers. It is possible that this creates a selection bias. Because these teachers have volunteered to be a part of the study, they may have had an incentive to see the study succeed or fail based on their feelings toward the use of CPS or PI. Both these teachers had minimal prior experience with CPS. However, training on how to use the CPS technology and ongoing technical support was provided to both teachers. The research results may have been different had both teachers had extensive experience in CPS prior to this study. Training was also provided to the teacher of the treatment group on how to incorporate PI with CPS.

The results of this study were generalized to one grade level of math students in one small rural school in northeast Georgia. Students in a different grade level, at a different school, in a different geographical location, or in a different subject area could have had different academic skills, weaknesses, or results.
While the 2010 ITBS Total Math score was used as a covariate to control for previous math achievement, there were several factors that were not considered. Factors such as additional math support, participation in before school or after school academic programs, extracurricular activities, family responsibilities, level of parental support/involvement, gender, ethnicity, or socio-economic status were not included in the statistical analysis. The researcher did not disaggregate student achievement or motivation data based upon the aforementioned categories because those categories were not related to the research questions.

There is also a validity threat with the teacher-created Unit 7 posttest. Although teachers and others professionals considered to be experts in math and the educational field validated the test, there was no statistical analysis conducted on the questions. It is possible that these questions are neither reliable nor valid. However, to reduce this threat, the test questions were specifically aligned to the objectives for the GPS math unit being taught.

The assumption of homogeneity of variance between the groups could not be assumed for the posttest results. Caution should be taken when interpreting the results of the posttest because there is an increased chance of a Type I error.

Surveys have inherent limitations. Technical glitches may occur in an online survey (University of Texas at Austin, 2008). Technical difficulties did occur during the survey in this research, thus decreasing the available results from participants in the treatment group and the control group. Therefore, the results of the study may be slightly skewed. In addition, online surveys must be completed in one sitting and cannot be saved and finished at a later date, thus students may have rushed through the survey if
little time remained in class (University of Saskatchewan, 2009). A major limitation of a survey is that “it relies on a self-report method of data collection. Intentional deception, poor memory, or misunderstanding of the questions can all contribute to inaccuracies in the data” (Maricopa Community College, n.d., para. 1). The teacher of each group encouraged students to be honest when answering the survey questions and made sure that students knew that the results of the survey were for research purposes only and that their class grade would not be affected in anyway as a result of their answers. Finally, the development of questions that would be general enough yet still appropriate for all participants to answer the researcher’s questions is difficult (Colorado State University, 2012). Because of this threat, the researcher used a validated survey instrument. Other survey instruments were considered, but the IMMS was chosen because the survey’s questions suited this research study. This particular study used a Likert scale with answers ranging from 1–5, creating the possibility of a midpoint system threat (Swain, Weathers, & Neidrich, 2008).

**Recommendations**

**Recommendations for practical applications.** An analysis of the data showed several practical recommendations and possibilities for further research. First, administrators should encourage teachers to step out of their comfort zones and incorporate CPS and/or other technologies into their weekly lesson plans (Lively, 2010). Second, administrators and teachers should search for possible grants to provide funding for CPS and then develop a checkout system for teachers who do not have a CPS in their classrooms (Lively, 2010). Third, due to today’s tough economy rather than hiring a technology coordinator instructional coordinator for individual schools, administrators
could consider assigning select personnel already employed at the school (such as the media specialist, instructional leader, or other computer literate personnel) to be responsible for learning how to use and implement CPS and PI and other related pedagogies. Fourth, administrators should search for creative ways to provide release time and training to teachers on how to properly implement CPS and PI (Lively, 2010).

**Recommendations for future research.** The findings of this study support the idea that CPS-based math instruction in conjunction with PI can increase student achievement and motivation in eighth grade students. The findings of this study also suggest that future studies extending the use of PI pedagogy with CPS to math units might show increased student achievement and motivation. While this study demonstrated that PI is an appropriate pedagogy to incorporate with the use of CPS in eighth grade math students, the strategies may need to be modified to meet the needs of other students. More research should be done which utilizes CPS technology along with specific types of pedagogy other than PI. These strategies might include Assessing to Learn (Dufresne & Gerace, 2004), Interactive Engagement (Hake, 1998), or Technology-Enhanced-Formative Assessment (Beatty & Gerace, 2009).

Results from this study indicated that CPS-based instruction with PI increases students’ attentiveness and view of math’s relevance. Using CPS-based instruction with PI in math may be effective for students with disabilities such as those with Attention Deficit with Hyperactivity Disorder. If the students see math as relevant and can pay attention, then the instruction could be more effective. If the instruction is more effective, then test scores may increase. If tests scores increase, then the school is much more likely to meet AYP. This implication is an area of importance to the research site
because students with disabilities historically have problems meeting the minimum requirements for high-stakes testing, and each year the research site’s AYP success hinges on the math scores of students with disabilities.

Further research could be undertaken that would survey and use a validated instrument that investigates the perceptions of teachers and students regarding the use of CPS with and without PI in the K–12 setting. If no such survey instrument exists, then research could be conducted that leads to the creation of a validated survey pertaining to the perceptions of teachers and students who have used CPS with and without PI.

Research could be conducted that further investigates student motivation regarding the use of CPS with PI by incorporating a qualitative component. This type of research could include focus groups and/or interviews of students in the K–12 setting.

Further research could be conducted that investigates the impact of various demographic differences on student achievement and student motivation among students who use CPS with PI in the K–12 setting. These differences could include factors such as gender, ethnicity, and socioeconomic status.

Further research could be conducted that isolates various variables that might influence student achievement or student motivation. These variables could include but are not limited to variables such as additional math support before, during, or after the school day; participation in afterschool activities; family responsibilities; and level of parental support among students who use CPS with PI in the K–12 setting.

Further research could be conducted that utilizes a 2 x 4 factorial design. One group would receive CPS-based instruction only. One group would receive PI-based
instruction only. One group would receive CPS-based instruction with PI. One group would receive no CPS- or PI-based instruction.

Replication of this study could be done with any of the following variations: (a) using a more valid instrument other than an expert-validated posttest for measuring student achievement, (b) using an expert-validated test with more than 10 questions, (c) using a different validated survey for measuring motivation, (d) expanding the length of time for the instructional unit beyond a four-week unit, (e) using a different unit of study in math; (f) using a different subject area, (g) using a different grade level in the K–12 setting, and (h) using a study based upon and designed according to Keller’s (2006b) ARCS Model of Design.

**Conclusion**

The results of this study indicated that eighth grade students who received CPS-based math instruction combined with PI showed a statistically significant difference in posttest scores compared to eighth grade students who received CPS-based math instruction without PI. The findings from this study also demonstrated that student mean scores for motivation were statistically significantly different on two out of four subscales for eighth grade students who received CPS-based math instruction in conjunction with PI compared to eighth grade students who did not receive CPS-based math instruction with PI. Thus, this study suggests that the variable of PI used in conjunction with CPS has a positive effect on enhancing student achievement and certain aspects of student motivation in eighth grade students.
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APPENDIX A: UNIT 7 POSTTEST–SYSTEM OF EQUATIONS AND INEQUALITIES

Student Name: _____________________________    Date: _____________________

Directions: Please read each question carefully to make sure you use the appropriate method to solve each question. Each question answered correctly will be worth 10 points each. Be sure to show your all your work on the test paper. Partial credit will be given based on work shown.
1. Use elimination to find the solution to the system of equations.

   \[ 7x + 3y = -40 \]
   \[ 3x + 9y = -48 \]

- A. \( x = -4, y = -4 \)
- B. \( x = -37, y = 7 \)
- C. \( x = \frac{-46}{7}, y = 2 \)
- D. \( x = -3, y = \frac{-13}{3} \)

2. The system of equations

   \[ 4x - 3y = -5 \]
   \[ 3x + 5y = -11 \]

is graphed below. Find the solution to the system.

- A. \( x = 2, y = -1 \)
- B. \( x = -2, y = -1 \)
- C. \( x = 2, y = 1 \)
- D. \( x = -2, y = 1 \)
3. Which set of inequalities best represents the graph shown above?

A. $y < -\frac{1}{2}x + 5$
   $x > -2$
   $y \geq -2$

B. $y > -\frac{1}{2}x + 5$
   $x > -2$
   $y \geq -2$

C. $y \geq -\frac{1}{2}x + 5$
   $x \geq -2$
   $y > -2$

D. $y \leq -\frac{1}{2}x + 5$
   $x \geq -2$
   $y > -2$

4. A tent manufacturer makes a standard model and an expedition model. Each standard tent requires 1 labor-hour from the cutting department and 3 labor-hours from the assembly department. Each expedition tent requires 2 labor-hours from the cutting department.
and 4 labor-hours from the assembly department. The maximum labor-hours available per day in the cutting department and the assembly department are 24 and 60, respectively.

The company makes a profit of $43 on each standard tent and $56 on each expedition tent. Use the information below:

Let \( x \) = standard tents
Let \( y \) = expedition tents

Then \( x + 2y \leq 24 \)
and \( 3x + 4y \leq 60 \).

The graph of these functions is shown to the right. It is impossible to produce a negative number of tents, so \( x \) and \( y \) both have to be greater than zero. Therefore, the functions are confined to the first quadrant.

Profit function:
\[ P = 43x + 56y \]

How many tents of each type should be manufactured each day to maximize the total daily profit?

- **A.** 0 standard tents and 12 expedition tents
- **B.** 12 standard tents and 6 expedition tents
- **C.** 20 standard tents and 0 expedition tents
- **D.** 0 standard tents and 15 expedition tents

5. The system of equations

\[
\begin{align*}
-2x - 3y &= 10 \\
-3x + 5y &= -4
\end{align*}
\]

is graphed below. Find the solution to the system.
6. At the football game, 2 hamburgers and 5 soft drinks cost $18, and 4 hamburgers and 3 soft drinks cost $22. Which system of linear equations below can be used to determine the price of a hamburger and the price of a soft drink?

(Let x represent the cost of a hamburger and y represent the cost of a soft drink)

- **A.** $6x + 8y = 40$
- **B.** $2x + 5y = 18$
  $4x + 3y = 22$
- **C.** $2x + 4y = 18$
  $5x + 2y = 22$
- **D.** $2x + 4x = 24$
  $5y + 3y = 16$
7. Use substitution to solve for $x$ in the system of equations.

\[ 10x + 2y = 52 \]
\[ 3x + y = 8 \]

- A. $x = 11$
- B. $x = -9$
- C. $x = 13$
- D. $x = 9$

8. Which set of inequalities best represents the graph shown above?

- A. $y > x - 4$
  $x \geq -2$
  $y < 4$

- B. $y \geq x - 4$
  $x > -2$
  $y \leq 4$

- C. $y < x - 4$
  $x \geq -2$
  $y < 4$
9. At the afternoon matinee movie 2 adult tickets and 4 child tickets cost $32, and 5 adult tickets and 3 child tickets cost $52. Which system of linear equations below can be used to determine the price of each ticket?

(Let \(x\) represent the cost of an adult ticket and \(y\) represent the cost of a child ticket)

- **A.** \(2x + 5y = 32\)
  \(4x + 4y = 52\)

- **B.** \(2x + 4y = 32\)
  \(5x + 3y = 52\)

- **C.** \(7x + 7y = 84\)

- **D.** \(2x + 5x = 56\)
  \(4y + 3y = 28\)

10. Use elimination to find the solution to the system of equations.

\[
\begin{align*}
4x + y &= 6 \\
3x - 2y &= 10
\end{align*}
\]

- **A.** \(x = \frac{10}{3}, y = 0\)
- **B.** \(x = 2, y = -2\)
- **C.** \(x = \frac{28}{3}, y = 9\)
- **D.** \(x = 9, y = -30\)
APPENDIX B: EXPERT VALIDATION OF UNIT 7 POSTTEST–SYSTEMS OF EQUATIONS AND INEQUALITIES

ALGEBRA
Students will use linear algebra to represent, analyze and solve problems. They will use equations, tables, and graphs to investigate linear relations and functions, paying particular attention to slope as a rate of change.

M8A5. Students will understand systems of linear equations and inequalities and use them to solve problems.

a. Given a problem context, write an appropriate system of linear equations or inequalities
b. Solve systems of equations graphically and algebraically, using technology as appropriate.
c. Graph the solution set of a system of linear inequalities in two variables.
d. Interpret solutions in problem contexts.

Directions: Based upon the attached teacher-made test, please answer the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Number of Yes Responses</th>
<th>Number of No Responses</th>
<th>Comments/Suggestions</th>
<th>Percentage of Yes Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the test have clear, complete directions?</td>
<td>11</td>
<td>0</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Do the test questions measure the specific elements of the math standards listed?</td>
<td>10</td>
<td>1</td>
<td></td>
<td>90.91%</td>
</tr>
<tr>
<td>Do the test questions use the language of the standard?</td>
<td>11</td>
<td>0</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Is an adequate number of questions included per element for this standard?</td>
<td>10</td>
<td>1</td>
<td>Not difficult enough</td>
<td>90.91%</td>
</tr>
<tr>
<td>Do you think the level of the test is appropriate?</td>
<td>10</td>
<td>1</td>
<td></td>
<td>90.91%</td>
</tr>
<tr>
<td>Do you think that students will have sufficient time to complete this test in a 50 to 60 minute class time?</td>
<td>11</td>
<td>0</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
# APPENDIX C: TABLE OF SPECIFICATIONS FOR POSTTEST

## TABLE OF SPECIFICATIONS FOR 8TH GRADE MATH
### UNIT 7 POSTTEST

<table>
<thead>
<tr>
<th>8th Grade GPS Standards and Elements</th>
<th>Pretest/Posttest Question(s) Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>M8A5</td>
<td></td>
</tr>
<tr>
<td>Students will understand systems of linear equations and inequalities and use them to solve problems.</td>
<td></td>
</tr>
<tr>
<td>a. Given a problem context, write an appropriate system of linear equations or inequalities.</td>
<td>#6, 9</td>
</tr>
<tr>
<td>b. Solve systems of equations graphically and algebraically, using technology as appropriate.</td>
<td>#1, 2, 5, 7, 10</td>
</tr>
<tr>
<td>c. Graph the solution set of a system of linear inequalities in two variables.</td>
<td>#3, 8</td>
</tr>
<tr>
<td>d. Interpret solutions in problem contexts.</td>
<td>#4, 6, 9</td>
</tr>
</tbody>
</table>
# APPENDIX D: EDUCATOR QUALIFICATIONS FOR VALIDATION OF 7TH GRADE MATH POSTTEST

<table>
<thead>
<tr>
<th>Educator</th>
<th>Position(s) Held</th>
<th>Years in Position(s)</th>
<th>Degree(s) Held</th>
<th>Certifications/Endorsements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7th Grade Math Teacher</td>
<td>16</td>
<td>BS; MEd; EdS</td>
<td>Middle Grades Math/Science</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8th Grade Math Teacher</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7th Grade Math/Science teacher</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6th Grade Science Teacher</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>High School Math Teacher</td>
<td>31</td>
<td>BS; MEd Mathematics</td>
<td>Leadership Certification</td>
</tr>
<tr>
<td></td>
<td>Gifted Program Coordinator</td>
<td>4</td>
<td>EdS Teaching and Learning</td>
<td>Gifted Endorsement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8th Grade Math Teacher</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Middle School Assistant Principal</td>
<td>1</td>
<td>BS Agricultural Economics</td>
<td>Leadership Certification</td>
</tr>
<tr>
<td></td>
<td>Middle School Math/Science Teacher</td>
<td>8</td>
<td>MPA Public Administration EdS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Curriculum and Instruction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grade</td>
<td>Position</td>
<td>Degree Holders</td>
<td>Program</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
<td>-----------------------------------------------</td>
<td>----------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>8th</td>
<td>8th Grade Special Education Math Teacher</td>
<td>2</td>
<td>BS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Middle Grades Math/Social Sciences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6th Grade Special Education Math/Language Arts/Reading Teacher</td>
<td>1</td>
<td>MEd</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Middle Grades Math</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7th Grade Special Education Math Teacher</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8th Grade Special Education Georgia History Teacher</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>8th Grade Math Teacher</td>
<td>2</td>
<td>BA; MEd</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Middle Grades Math/Social Sciences</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Secondary Curriculum Director/School Improvement Director</td>
<td>3</td>
<td>BS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle School Teacher</td>
<td>3</td>
<td>Math Education</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MEd; EdS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High School Teacher</td>
<td>1</td>
<td>Educational Leadership</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle School Assistant Principal</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>High School Assistant Principal</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>High School Principal</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Georgia Department of Education Program Manager</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Grade/Position</td>
<td>Credits</td>
<td>Major/Field</td>
<td>Certification</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>---------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>7</td>
<td>6th–8th Grade Middle School ESOL Math/Language Arts Teacher</td>
<td>3</td>
<td>BA; MBA Business Administration</td>
<td>K–12 ESOL Certification</td>
</tr>
<tr>
<td></td>
<td>Elementary Teacher</td>
<td>7</td>
<td>MAT Middle Grades</td>
<td>K–5 Elementary Certification</td>
</tr>
<tr>
<td></td>
<td>ESL Adult Education Instructor</td>
<td>10</td>
<td>EdS Curriculum and Instruction</td>
<td>6–12 Broad-field Social Sciences Certification</td>
</tr>
<tr>
<td>8</td>
<td>8th Grade Middle School Math Teacher</td>
<td>15</td>
<td>BS; MEd Middle Grades Math/Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6th Grade Math/Science Teacher</td>
<td>4</td>
<td>EdS Instructional Design/Technology/Curriculum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6th Grade Social Studies/Science Teacher</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>6th–8th Grade Math Teacher-Gifted</td>
<td>4</td>
<td>BS; MEd Middle Grades Math</td>
<td>Gifted Endorsement</td>
</tr>
<tr>
<td></td>
<td>7th–8th Grade Language Arts Teacher-Gifted</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>7th Grade Middle School Math Teacher</td>
<td>23</td>
<td>BA Middle Grades Math/ Language Arts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5th Grade Elementary Teacher</td>
<td>2</td>
<td>MEd Middle Grades Math/Reading/Language Arts</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E: SAMPLE MOTIVATION SURVEY–INSTRUCTIONAL MATERIALS MOTIVATION SURVEY (IMMS)

Table 11.8. The Instructional Materials Motivation Survey Instrument.

<table>
<thead>
<tr>
<th>Instructions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>There are 36 statements in this questionnaire. Please think about each statement in relation to the instructional materials you have just studied and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true, or what you think others want to hear. Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements. Record your responses on the answer sheet that is provided and follow any additional instructions that may be provided in regard to the answer sheet that is being used with this survey. Thank you. Use the following values to indicate your response to each item.</td>
<td></td>
</tr>
<tr>
<td>1 (or A) = Not true</td>
<td></td>
</tr>
<tr>
<td>2 (or B) = Slightly true</td>
<td></td>
</tr>
<tr>
<td>3 (or C) = Moderately true</td>
<td></td>
</tr>
<tr>
<td>4 (or D) = Mostly true</td>
<td></td>
</tr>
<tr>
<td>5 (or E) = Very true</td>
<td></td>
</tr>
<tr>
<td>1. When I first looked at this lesson, I had the impression that it would be easy for me.</td>
<td></td>
</tr>
<tr>
<td>2. There was something interesting at the beginning of this lesson that got my attention.</td>
<td></td>
</tr>
<tr>
<td>3. This material was more difficult to understand than I would like for it to be.</td>
<td></td>
</tr>
<tr>
<td>4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.</td>
<td></td>
</tr>
<tr>
<td>5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.</td>
<td></td>
</tr>
<tr>
<td>6. It is clear to me how the content of this material is related to things I already know.</td>
<td></td>
</tr>
<tr>
<td>7. Many of the pages had so much information that it was hard to pick out and remember the important points.</td>
<td></td>
</tr>
<tr>
<td>8. These materials were eye-catching.</td>
<td></td>
</tr>
<tr>
<td>9. There were stories, pictures, or examples that showed me how this material could be important to some people.</td>
<td></td>
</tr>
<tr>
<td>10. Completing this lesson successfully was important to me.</td>
<td></td>
</tr>
<tr>
<td>11. The quality of the writing helped to hold my attention.</td>
<td></td>
</tr>
<tr>
<td>12. This lesson is so abstract that it was hard to keep my attention on it.</td>
<td></td>
</tr>
<tr>
<td>13. As I worked on this lesson, I was confident that I could learn the content.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F: APPROVAL EMAIL FROM IMMS AUTHOR, JOHN KELLER, TO USE/MODIFY IMMS SURVEY

From: John Keller <j.keller@arcmodel.com>
To: Tracy H. Allsen
Subject: Would like your permission to use/modify IMMS

Dear Tracy,

Thank you for your interest in the arcs model. I have attached a chapter from my book which combines two motivational instruments as well as scoring and psychometric information. You are welcome to use the IMMS and it is expected that it will be modified to reflect the setting in which it is being administered. I have also attached some articles which might be useful if you have not already seen them.

Your study sounds interesting. A colleague of mine who is in the math department here at Florida State University has done extensive work with clickers and, more recently, mobile phones in math instruction.

Sincerely,
John

John M. Keller, Ph.D.
Professor Emeritus
Educational Psychology and Learning Systems
Florida State University
9705 Natese Mocc Drive
Tallahassee, FL 32313-2746
Phone: 850-244-2550

Official ARCS Model Website: http://arcmodel.com

Professional Website: http://mailer.fsu.edu/~faculty/johnkeller/


"Good judgment comes from experience, and a lot of that comes from bad judgment." From "Don't Squat with Your Spurs On: A Cowboy's Book of Wisdom."

---Original Message---
From: Tracy H. Allsen Email: TAHill@WheatonCollegeV12.edu
March 2, 2011

To Whom It May Concern:

I (name removed) grant permission to allow Tracy Allison to conduct a quantitative study examining the impact of a classroom performance system and the use of peer instruction upon student achievement and student motivation of middle school students to be conducted at (name removed). I understand that the information gathered would be for research purposes only, and the identity and identifying information of all participants will be kept confidential.

Sincerely.

(name removed)
March 2, 2011

To Whom It May Concern:

I (name removed) grant permission to allow Tracy Allison to conduct a quantitative study examining the impact of a classroom performance system and the use of peer instruction upon student achievement and student motivation of middle school students to be conducted at (name removed). I understand that the information gathered would be for research purposes only, and the identity and identifying information of all participants will be kept confidential.

Sincerely,

(Name removed)
March 10, 2011

Tracy Allison
IRB Approval 1071.030911: What is the Impact of a Classroom Performance System upon Middle School Students?

Dear Tracy,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Thank you for your cooperation with the IRB and we wish you well with your research project.

Sincerely,

Fernando Garzon, Psy.D.
IRB Chair
Associate Professor
Liberty University
1971 University Blvd
Lynchburg, VA 24502
(434) 592-4054
APPENDIX J: ADULT PARTICIPANT CONSENT FORM-ENGLISH

You are being asked to participate in a project as a doctoral class assignment under the direction of Dr. Randall S. Dunn and conducted through Liberty University. The University in accordance with its policy regarding the Protection of Human Research Subjects asks that you give your signed agreement to participate in this project. Please ask the doctoral student researcher, Tracy M. Allison, any questions you have to help you understand this research project. A basic explanation of the research is given below.

The researcher intends to investigate the impact of the implementation of a Classroom Performance System (CPS) with Peer Instruction in the middle school classroom on student achievement as well as to gather perceptions and assess motivation of students using such technology and pedagogy. The researcher will ask you to create and administer an expert-validated pre- and post end-of-unit assessment, use CPS two times per week during the four-week unit of study, and to administer two online student surveys at the end of the unit. The evaluation of the research proposal will include pre- and post-data compilation and interpretation and scheduled surveys after parent permission is obtained.

Your name will remain confidential at all times. You will not be identified in the research report.

Liberty University is an equal opportunity educational institution. It is not the intent of the institution to discriminate against any person based on sex, race, religion, color, national origin or handicap of the individual.

Questions regarding the conduct of this research may be directed to me, Tracy M. Allison, at (706) 778-7121 or at my email address tmallison@liberty.edu or my dissertation committee chair, Dr. Randall S. Dunn at 1-800-424-9595 or email him at rdunn@liberty.edu.

Refusal to participate in this study will have no effect on any future services you may be entitled to from the school system. Should you agree to participate in this study and decide later that you wish to withdraw, you will be free to withdraw from the study at any time without penalty. If you agree to participate at this time, please sign and date this statement. You may keep a copy of this consent form for your records. Thank you very much for your willingness to participate in this research project.

Teacher Name (printed): ______________________________________________________

Teacher Signature: ______________________________ Date: ______________

School Administrator Signature: __________________________ Date: ______________

Copy on File

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APPENDIX K: STUDENT PARTICIPANT CONSENT FORM-ENGLISH

Introduction: You child is being asked to participate in a research project as a doctoral class assignment under the direction of Dr. Randall S. Dunn and conducted through Liberty University. The University in accordance with its policy regarding the Protection of Human Research Subjects asks that you give your signed agreement to participate in this project. The researcher intends to examine the impact of the implementation of Classroom Performance System (CPS) technology, also commonly referred to as ‘clickers’, with a research based-pedagogy, Peer Instruction, in 8th grade math classes upon student achievement and to assess student motivation using such technology and pedagogy. The researcher will not be directly involved in the research process. Your child was selected as a possible participant because he/she may fit the criteria for this study (i.e. middle school math student) and he/she is enrolled in an 8th grade math class whose teacher will be participating in a research project in order to facilitate a candidate in the SOE dissertation process. This informed consent outlines the facts, implications, and consequences of the research study. A basic explanation of the procedures for the research is given below.

Inquiries: Please ask the doctoral student researcher, Tracy M. Allison, any questions you have to help you understand this research project. The researcher will gladly answer any inquiries regarding the purpose and procedures of the present study. Inquiries or questions regarding this research may be directed to me, Tracy M. Allison, at (706) 778-7121 or at my email address tmallison@ liberty.edu or my instructor, Dr. Randall S. Dunn, at 1-800-424-9595, or email him at rdunn@liberty.edu. If you or your parents have any questions about rights or this form, please email the current IRB chair for Liberty University, Dr. Fernando Garzon, at irb@liberty.edu.

Liberty University is an equal opportunity educational institution. It is not the intent of the institution to discriminate against any person based on sex, race, religion, color, national origin or handicap of the individual.

Procedures: Your child’s teacher will create and administer an expert-validated pre- and post end-of-unit assessment over the standards taught in one unit of math instruction. The teacher will use clickers two times per week during the four-week unit of study. At the end of the unit, your child will be asked to complete an online student survey consisting of approximately 36 questions including questions about demographics and student motivation about the implementation of clickers with or without Peer Instruction into the 8th grade math classroom. The length of time needed to complete the online survey is estimated to be approximately 20 minutes of class time. The evaluation of the research proposal will include pre- and post-data compilation and interpretation and scheduled survey after parent permission is obtained. Participation will be anonymous and voluntary.

Untried/ Risks: The researcher will use multiple-choice questions based upon a previously used survey instrument regarding clicker and/or peer instruction for students at the college level but which may have not been used previously with middle school students. The study may involve risks to the participant, which are currently unforeseeable.

Benefits: Participants may benefit from increased understanding of the use of clickers using a research-based pedagogy. The potential publication of the findings of this study may prove beneficial to students, faculty, and higher education administrators as they seek to proactively
improve the use of technology along with a specific pedagogy in order to increase student achievement, student perceptions, and student motivation of middle school math students.

**Compensation:** Participants will not receive compensation for participation.

**Participation:** Refusal to participate in this study will have no effect on your grade or any future services you may be entitled to from the school system. Should you agree to participate in this study and decide later that you wish to withdraw, you will be free to withdraw from the study at any time without penalty. If you agree to participate at this time, please sign and date this statement. You may keep a copy of this consent form for your records. Thank you very much for your willingness to participate in this research project.

**Confidentiality:** The researcher will take precautions to protect participant identity by not using the names of participants or a specific class period in her results or writing. However, since this study is limited to students in one of two middle schools in one school system, the identities of the participants could be inferred. The survey will be located on a secure online server. Data is stored on the server and is kept in a password-protected database. It is conceivable that engineering staff at the web hosting company may need to access the database for maintenance reasons and research assistants may also access data when collecting and analyzing data. The information will be stored on the survey site for the duration of three years and will then be deleted by the researcher. The researchers will store all research documentation on a password-protected portable hard drive for the duration of three years and will then delete the documentation from the computer database. Any hard copies of the data will be stored in a locked filing cabinet and shredded at the end of three years.

**Statement of Consent:** South Habersham Middle School and Liberty University, their agents, trustees, administrators, faculty, and staff are released from all claims, damages, or suits, not limited to those based upon or related to any adverse effect upon you which may arise during or develop in the future as a result of my participation in this research. (Please understand that this release of liability is binding upon you, your heirs, executors, administrators, personal representatives, and anyone else who might make a claim through or under you.)

-------------------------------------------------------------------------------------------------------------------

**Student Name (printed):** __________________________________________________

**Student Signature:** _________________________________  **Date:** _______________

**Parent Signature:** _________________________________  **Date:** _______________
APPENDIX L: STUDENT PARTICIPATION CONSENT FORM-SPANISH

Introducción: Su hijo está siendo invitado a participar en un proyecto de investigación como una tarea de clase doctoral bajo la dirección del Dr. Randall S. Dunn y llevó a cabo a través de Liberty University. La Universidad de conformidad con su política de Protección de Sujetos Humanos de Investigación le pide que dé su acuerdo firmado para participar en este proyecto. El investigador tiene la intención de examinar el impacto de la aplicación del Aula del rendimiento del sistema (CPS) de tecnología, también se conoce comúnmente como "clickers", con una investigación basada en la pedagogía, Peer Instrucción, en el 8 o grado de las clases de matemáticas a los logros de los estudiantes y para evaluar estudiantes motivación utilizando dicha tecnología y la pedagogía. El investigador no estará directamente involucrado en el proceso de investigación. Su hijo ha sido seleccionada como participante posible porque él / ella puede cumplir los criterios para este estudio (es decir, los estudiantes de matemática de la escuela) y él / ella se inscribió en una clase de matemáticas de 8 o grado cuyo maestro estará participando en un proyecto de investigación con el fin de facilitar un candidato en el proceso de tesis de SOE. Este consentimiento informado se expondrán los hechos, las implicaciones y consecuencias de la investigación. Una explicación básica de los procedimientos de la investigación se da a continuación.

Preguntas: Por favor, pregunte el investigador doctorando, Tracy M. Allison, cualquier duda que tenga para ayudar a entender este proyecto de investigación. El investigador estará encantado de contestar cualquier pregunta sobre el propósito y los procedimientos del presente estudio. Cualquier pregunta o preguntas con respecto a esta investigación podría ser dirigida a mí, Tracy M. Allison, en el (706) 778-7121 o en mi tmallison@liberty.edu dirección de correo electrónico o mi instructor, el Dr. Randall S. Dunn, al 1-800-424-9595, o email él en rdunn@liberty.edu. Si usted o sus padres tiene alguna pregunta acerca de los derechos o la forma de este, por favor escriba el actual presidente del IRB para la Libertad de la Universidad, el Dr. Fernando Garzón, en irb@liberty.edu.

Liberty University es una institución de igualdad de oportunidad educativa. No es la intención de la institución de discriminar contra cualquier persona por razón de sexo, raza, religión, color, origen nacional o discapacidad del individuo.

Procedimiento: El maestro de su niño va a crear y administrar un experto validados antes y después de la evaluación al final de su unidad sobre los estándares enseñados en una unidad de enseñanza de las matemáticas. El maestro se usarán contadores dos veces por semana durante la unidad de cuatro semanas de estudio. Al final de la unidad, su hijo tendrá que completar una encuesta de estudiantes en línea que consiste en aproximadamente 36 preguntas que podrán incluir preguntas sobre la demografía y la motivación de los estudiantes sobre la aplicación de clickers con o sin el par de instrucciones en el aula de matemáticas de 8 o grado. El tiempo necesario para completar la encuesta en línea se estima en aproximadamente 20 minutos de tiempo de clase. La evaluación de la propuesta de investigación se incluyen pre-y post-compilación e interpretación de datos y la encuesta programada después de permiso de los padres se obtiene. La participación será voluntaria y anónima.

Espera de juicio / Riesgos: El investigador utilizará preguntas de opción múltiple basadas en un instrumento de encuesta utilizado anteriormente en relación clicker y / o instrucción entre pares
para estudiantes a nivel universitario, pero que no puede haber sido utilizado previamente con los estudiantes de escuela intermedia. El estudio puede implicar riesgos para el participante, que actualmente son imprevisibles.

**Beneficios:** Los participantes podrán beneficiarse de una mayor comprensión de la utilización de clickers usando una pedagogía basada en la investigación. La posible publicación de los resultados de este estudio pueden resultar beneficiosos para los estudiantes, profesores y administradores de la educación superior en sus esfuerzos por mejorar de forma dinámica el uso de la tecnología, junto con una pedagogía específica para aumentar el rendimiento estudiantil, las percepciones de los estudiantes, y la motivación de los estudiantes de estudiantes de secundaria de matemáticas.

**Retribución:** Los participantes no recibirán compensación por la participación.

**Participación:** La negativa a participar en este estudio no tendrá ningún efecto en su grado o cualquier servicio futuro que puede tener derecho a la del sistema escolar. Si usted de acuerdo en participar en este estudio y más tarde decide que desea retirarse, usted tendrá la libertad de retirarse del estudio en cualquier momento sin penalización. Si usted acepta participar en este momento, por favor, firmar y fechar la declaración de este. Usted puede guardar una copia de este formulario de consentimiento para su archivo. Muchas gracias por su disposición a participar en este proyecto de investigación.

**Confidencialidad:** El investigador tomará las precauciones necesarias para proteger la identidad de los participantes por no usar los nombres de los participantes o de un período de clases específicas en sus resultados o la escritura. Sin embargo, ya que este estudio se limita a los estudiantes en una de las dos escuelas intermedias en el sistema escolar, la identidad de los participantes podría ser deducido. La encuesta se encuentra en un servidor en línea seguro. Los datos se almacenan en el servidor y se guarda en una base de datos protegida por contraseña. Es concebible que el personal de ingeniería de la empresa de alojamiento web puede ser necesario para acceder a la base de datos por razones de mantenimiento y asistentes de investigación también pueden acceder a los datos en la recopilación y análisis de datos. La información se almacena en el sitio de la encuesta de la duración de tres años y luego será eliminado por el investigador. Los investigadores se almacenará toda la documentación de la investigación en una protegida por contraseña disco duro portátil para la duración de tres años y luego eliminar la documentación de la base de datos informática. Todas las copias impresas de los datos se almacenarán en un archivador bajo llave y destruido al final de tres años.

**Declaración de Consentimiento:** Sur Habersham Middle School y la Universidad de la Libertad, sus agentes, custodios, administradores, profesores y empleados se liberan de todas las demandas, daños, o trajes, no se limita a los basados en o relacionados con ningún efecto adverso sobre ti que puede surgir durante o desarrollar en el futuro como resultado de mi participación en esta investigación. (Por favor, comprenda que esta liberación de responsabilidad civil es obligatorio para usted, sus herederos, ejecutores, administradores, representantes personales, y cualquier otra persona que pueda hacer una reclamación a través de o debajo de ti.)

Nombre del alumno (letra de molde): _________________________________________
Firma del Estudiante: _________________________________ Fecha: ______________
Firma del padre: ____________________________________ Fecha: ____________
March 11, 2011
Dear Parents and Students:

As a teacher at South Habersham Middle School (SHMS) and as a doctoral candidate at Liberty University, I am honored to have the opportunity to work with your child’s math teacher in using technology in the classroom called a Classroom Performance System, often referred to as ‘clickers’. In addition to training your child’s teacher on how to use this technology, I will also provide specific instructional strategies for using the ‘clickers’ in the classroom.

As a result of this teacher training, your child’s math teacher will use this technology with all students to teach a four-week math unit in the classroom. The teacher will be able to use this technology and teaching strategies as tools, which may help improve student achievement and motivation by providing instant feedback to all students. Thus, the teachers will be able to use data obtained from the clicker questions in order to immediately guide, drive, and change instruction rather than wait until test time to know how your child is performing. Your child’s teacher has created a pretest and posttest that will be given to all students to determine mastery of the math standards for the instructional unit.

Much research is available at the collegiate level that supports the use of this technology along with specific teaching strategies. I would like to examine the results at the middle school level. This type of technology is already used on a routine basis in several other classes at SHMS. However, in order to examine a statistical impact of this technology and methodology in your child’s math class, I need to obtain your prior written consent. Participation would in no way affect your child’s grade; however, it is hoped that your child’s grades would improve as a result of using the technology with specific teaching strategies. Your child’s name or other identifying information would not be used anywhere in the study.

I am asking your help in explaining this process to your child and am asking for permission to use and analyze your child’s student achievement data and responses to an online survey at the end of the math unit. Your child’s math teacher will use the technology and will administer a pre- and posttest to all students in the classroom regardless of parent consent to participate in the research study. However, without parent and student permission, no student achievement data or survey responses can be used in my study.

The school superintendent and school principal have granted permission for me to engage in this research at SHMS.

For more specific information concerning this study, please see the attached Parent/Student Consent form, or please contact me.

Sincerely,
Tracy M. Allison, Teacher
12 de marzo 2011

Queridos Padres y Estudiantes:

Como profesor en el South Habersham Middle School (SHMS) y como un candidato doctoral en la Universidad Liberty, me siento honrado de tener la oportunidad de trabajar con el maestro de matemáticas de su hijo en el uso de la tecnología en el aula llamado Aula del rendimiento del sistema, a menudo referido como 'clickers'. Además de la formación del profesorado de su hijo sobre cómo utilizar esta tecnología, también proporcionará estrategias de enseñanza específica para el uso del 'clickers' en el aula.

Como resultado de esta formación del profesorado, el maestro de su hijo matemáticas usará esta tecnología con todos los estudiantes para enseñar una unidad de matemáticas de cuatro semanas en el aula. El maestro será capaz de utilizar esta tecnología y estrategias de enseñanza como herramientas, que pueden ayudar a mejorar el rendimiento de los estudiantes y la motivación, proporcionando información instantánea a todos los estudiantes. Por lo tanto, los profesores podrán utilizar los datos obtenidos a partir de las preguntas clicker a fin de orientar de inmediato, la unidad, y la instrucción cambio en lugar de esperar hasta el tiempo de prueba para saber cómo su hijo se está realizando. El maestro de su hijo ha creado un pretest y posttest que se le dará a todos los estudiantes para determinar el dominio de los estándares de matemáticas para la unidad de instrucción.

Muchas investigaciones se encuentra disponible a nivel universitario que apoya el uso de esta tecnología junto con las estrategias de enseñanza específicas. Me gustaría examinar los resultados a nivel de escuela intermedia. Este tipo de tecnología ya se utiliza de forma rutinaria en varias otras clases en SHMS. Sin embargo, con el fin de examinar un efecto estadístico de esta tecnología y metodología en la clase de matemáticas de su hijo, lo que necesito para obtener su consentimiento previo por escrito. La participación de ninguna manera afectar a su hijo de grado, sin embargo, se espera que las calificaciones de su hijo mejorará como resultado de la utilización de la tecnología con las estrategias de enseñanza específicos. El nombre de su hijo o con otra información de identificación no se utilizaría en cualquier parte del estudio.

Les pido su ayuda para explicar este proceso a su hijo y pido permiso para usar y analizar los datos de su hijo estudiante de los logros y las respuestas a una encuesta al final de la unidad de las matemáticas. El maestro de su hijo matemáticas utilizará la tecnología y administración de un pre-y posttest a todos los estudiantes en el aula, independientemente del consentimiento de los padres a participar en el estudio de investigación. Sin embargo, sin permiso de los padres y el estudiante, no hay datos logros de los estudiantes o respuestas a la encuesta puede ser utilizado en mi estudio. El superintendente de la escuela y el director de la escuela han concedido el permiso para mí participar en esta investigación en SHMS.

Para obtener información más específica acerca de este estudio, por favor consulte el documento de consentimiento, o póngase en contacto conmigo.

Atentamente,

Tracy M. Allison, Maestros
# APPENDIX O: SAMPLE OF ONLINE VERSION OF IMMS SURVEY

## Instructional Materials Motivation Survey

<table>
<thead>
<tr>
<th>2.</th>
<th>When I first looked at this unit, I had the impression that it would be easy for me.</th>
<th>My answer choice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not true</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Slightly true</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Moderately true</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Mostly true</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Very true</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.</th>
<th>There was something interesting at the beginning of this unit that got my attention.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>My answer choice</td>
</tr>
<tr>
<td></td>
<td>Not true</td>
</tr>
<tr>
<td></td>
<td>Slightly true</td>
</tr>
<tr>
<td></td>
<td>Moderately true</td>
</tr>
<tr>
<td></td>
<td>Mostly true</td>
</tr>
<tr>
<td></td>
<td>Very true</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.</th>
<th>This material was more difficult to understand than I would like for it to be.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>My answer choice</td>
</tr>
<tr>
<td></td>
<td>Not true</td>
</tr>
<tr>
<td></td>
<td>Slightly true</td>
</tr>
<tr>
<td></td>
<td>Moderately true</td>
</tr>
<tr>
<td></td>
<td>Mostly true</td>
</tr>
<tr>
<td></td>
<td>Very true</td>
</tr>
</tbody>
</table>