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Improving Student Achievement Through the Implementation of A Classroom Performance System

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Improving Student Achievement
Through the Implementation of a Classroom Performance System

by
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Approval Page

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Statement of Original Work

I declare the following:

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Abstract

Improving Student Achievement Through the Implementation of a Classroom Performance System. Stacy M. Artis, 2018: Applied Dissertation Nova Southeastern University, Abraham S. Fischler College of Education. Keywords: student achievement, student motivation, mathematics achievement, technology uses in education, handheld devices, ninth grade

This applied dissertation was designed to implement and examine the impact of a classroom performance system (CPS) on student achievement for Grade 9 mathematics students. Seventy-five students in 4 Coordinate Algebra classes were observed during the regular school day for 9 weeks. The treatment group received CPS-based instruction, and the control group received traditional mathematics instruction without the use of a CPS. The teacher was the same for all classes.

Data from benchmark assessments as well as quarterly grade reports were compared for both groups. The findings of this study showed mixed results in relation to the impact of CPS-based instruction on mathematics achievement. Using the CPS resulted in significant increases in benchmark scores but not report card scores; further, the increase in score was not statistically significantly different between the treatment and control groups. However, this research is an initial step in studying the use of CPSs with high school students; most of the research has investigated the use of CPSs at the college level.

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Chapter 1: Introduction

The Topic

The topic of this study is the improvement of student achievement and engagement in mathematics through the implementation of a classroom performance system (CPS). The CPS allows a teacher to present multiple-choice questions to students, who electronically respond through individual handheld devices. Because many companies offer many options that promise to transform teaching and increase student engagement, classrooms cannot continue to be a place where teachers expect students to take notes and do homework. Prensky (2008) stated that teachers should include more interaction in the classrooms and less direct instruction. Overall, student collaboration directly affects student achievement and growth (Prensky, 2008).

To fully affect student achievement and to improve 21st-century skills, students' mathematics achievement must improve (Huebner, 2010). According to Bell (2010), students have to learn to become responsible, independent, and disciplined to be successful by applying 21st-century skills. Some researchers have claimed that achievement in middle school mathematics is significant because students' engagement and attitude towards mathematics at that time affect later mathematical opportunities, which can further affect occupational opportunities (White-Clark, DiCarlo, & Gilchriest, 2008).

Researchers have found that students' attitudes, academic motivation, and engagement impact their academic achievement (Green et al., 2012; Lein et al., 2016). Teachers cannot necessarily control but can influence student attitudes towards mathematics, motivation, and engagement (Green et al., 2012). Among students with an early negative mindset, however, attitudes towards mathematics and motivation can be difficult to change. Teachers must make mathematics relevant to student lives, not an easy task to achieve. Sometimes, teachers have to modify lessons to help struggling mathematic students. According to Pellegrino and Quellmalz (2010), the integration of effective technology into mathematics classrooms can positively impact student engagement and motivation in learning mathematics. Therefore, teachers must plan to use different teaching techniques that deliver the content in a manner that struggling students can understand on the same level as nonstruggling students.

White-Clark et al. (2008) maintained that classrooms should have a creative, meaningful atmosphere. If students are engaged in their learning process, learning is guaranteed to take place. White-Clark et al. asserted that a lack of student engagement may be a primary reason for poor performance and motivation in the mathematics classroom. Teachers typically want to teach the way they were taught when they were in school. Some veteran teachers still try to teach students using traditional instruction by letting students take notes for future use (White-Clark et al., 2008).

An approach to increasing student engagement is through the use of a CPS (eInstruction, 2013). The CPS allows a teacher to present multiple-choice questions to students, who input their responses through individual handheld devices. This information can be displayed on the screen in the form of a table or graph. Even though students can see all responses, individual names and responses are kept anonymous (eInstruction, 2013).

Statement of the Problem

The problem this applied dissertation was designed to address was that the CPS has been implemented in the classroom, but its effectiveness has not been determined. Further, research is scarce on use of the CPS at the high school level rather than the university level. Even though the curriculum in many schools throughout the United States is intended to promote success on standardized tests, many students score at the needs improvement or basic proficiency level on these tests (Horn, 2006). This condition happens partly because many students perceive that the concepts they are learning are insignificant to their lives; as a result, the retention of concepts and engagement in classroom activities decreases (Boaler, 2006). Some have criticized the content students are expected to learn, whereas others blame the instructional approach taken by teachers (White-Clark et al., 2008).

In the fall of 2012, a new mathematics curriculum was implemented by all high schools in Georgia for ninth graders. The previous rigorous program, Mathematics 1, was replaced with an even more demanding program, Coordinate Algebra. Although research has shown a CPS to be a positive instructional tool, most studies investigating a CPS have focused on its use in higher education. Because of the correlation between student engagement and mathematics achievement for high school students, studies of the effectiveness of using a CPS with this population are necessary (Green et al., 2012).

Teachers of high school students may find effective engagement difficult (Duncan, 2006). Students may lack engagement in their learning due to typical teenage problems, excessive extracurricular activities, family issues, and language barriers. In addition, today's students are technology savvy, but most students go throughout the school day with little interaction with any type of technology. In the traditional school setting, students are expected to learn concepts through direct instruction and then practice those new skills by solving problems on a worksheet or from a textbook (Small Enterprises Research and Development Foundation, 2012). Using a CPS might be interesting enough to gain the attention of all students, including English language learners, unwilling learners, and disengaged students.

Background and Justification

With the improvements achieved in student response systems, D. Johnson and McLeod (2004) and Wang, Chung, and Yang (2014) declared that the popularity of CPSs has increased in the educational arena as a method of gaining instant feedback from students. Since 2013, the researcher's school has focused on improving teachers' formative assessment skills by having each teacher compose a data notebook. The data notebook helps teachers and administrators keep track of student achievement on targeted content by showing students' data and progress on specific learning targets. Without formative assessments, teachers have no evidence as to whether or not a lesson is helping students to meet learning standards (Hoffman & Goodwin, 2006). McTighe and O'Connor (2005) explained that CPSs enable teachers to give students timely feedback and help the teacher determine whether to move forward or review content taught during a lesson.

One of the major concerns of the teachers and administrators in the researcher's school district is student performance on state and national standardized testing. The CPS has been shown to raise standardized test scores (Hedgcock & Rouwenhorst, 2014). This type of system provides teachers with an easy way to track student progress toward meeting learning standards. Teachers who are aware of individual student progress can differentiate their instruction in a way that meets the needs of all students. Doing so increases student learning and improves test scores (Black, Harrison, Lee, Marshall, & Wiliam, 2004). Also, students have reported that they enjoy using the CPS, which leads to greater engagement and better understanding of the material the teacher presents (Byrd, Coleman, & Werneth, 2004).

As high-stakes tests have increased in importance for kindergarten through Grade 12 (K-12) education in the United States (No Child Left Behind Act, 2002), so has the need to focus student instruction on specific performance standards and the individual learning needs of each student. Educational leaders are always looking for ways to improve their instruction and assessment. One approach that teachers can use to develop lesson plans and activities and have effective instruction and assessment for the classroom is use of the CPS. These hardware and software systems allow student responses to be captured, stored, and reviewed for multiple levels of student assessment and analysis. Use of the CPS can help a teacher, school, and district identify an individual student's progress on the standards within the curriculum. Formative assessments and effective feedback can be a powerful method to improve student achievement and motivation (Cauley & McMillan, 2010).

According to Terrion and Aceti (2012), "Student engagement is important to learning because unengaged students do not listen, process, or attend to the learning process" (p. 12). Therefore, the use of a CPS, in combination with other teaching strategies, helps teachers fill the classroom with energy through active learning (Gely & Caron, 2004). Duncan (2006) indicated that when CPSs are used successfully, they should keep students engaged and motivated by providing immediate feedback about the students' understanding in the class. According to Gely and Caron (2004), the CPS should help students to maintain key concepts and to build on previous knowledge.

The setting. This applied dissertation took place at a public high school located in rural, central Georgia that is also the only public high school in the county. At the time of this study in 2016, the school enrollment summary data showed the school served 845 students, of whom 215 were ninth graders (Georgia Department of Education [GaDOE], 2016a, 2016b). The students ranged in age from 14 to 20 years old. The student body consisted of 53.5% female students and 46.5% male students. Approximately 72% of students were eligible for free or reduced-price lunch (GaDOE, 2016a). This school served a diverse ethnic population. The racial and ethnic breakdown of this school's population was 66.4% African American, 29.7% European American, 2.1% multiracial, 1.1% Hispanic, 0.4% Pacific Islander, and 0.4% Asian (GaDOE, 2016b). Seven percent of the students were identified as having some form of disability.

The Georgia Standards of Excellence replaced the Common Core Georgia Performance Standards in February 2015 (GaDOE, 2015). The Georgia Standards of Excellence in mathematics, including Coordinate Algebra, focus on actively engaging students and critical thinking (GaDOE, 2016c). Coordinate Algebra is the first of three high school courses designed to prepare students for college (GaDOE, 2016c).

Deficiencies in the evidence. The research of mathematics achievement and CPS has some deficiencies. Caldwell (2007) and Trees and Jackson (2007) provided literature on CPS and their use in colleges and universities. However, other researchers (Kay & LeSage, 2009; Penuel, Boscardin, Masyn, & Crawford, 2007; Wang et al., 2014) noted a lack of evidence in high school mathematics classrooms of how CPS impacts students. Researchers stressed the importance of further investigation into student engagement

(Blasco-Arcas, Buil, Hernández-Ortega, & Sese, 2013; Martin, Anderson, Bobis, Way, & Vellar, 2012). Of local importance, although CPSs have been implemented in the classroom, no study has determined their effectiveness on mathematics achievement.

Audience. This study was designed to fill a gap in the research regarding CPS use among high school students. Findings may be of interest to scholars and practitioners interested in methods of engaging ninth-grade mathematics students. The results are of direct importance to teachers and students at the study site.

Definition of Terms

Benchmark assessment. This term refers to student assessments used throughout a unit or course to monitor progress toward mastering learning goals and to guide instruction (Georgia Leadership Institute for School Improvement, 2013). The benchmark assessments in this study were designed by the researcher from a collection of questions published by Carnegie Learning (Snyder & Metz, 2012).

Classroom performance system (CPS). This term refers to a system that includes a set of student remotes, a teacher remote, and software that the teacher can use to prepare multiple-choice or survey questions. The system provides immediate feedback for the teacher to display to the students in the form of a graph or chart (eInstruction, 2013).

Clickers. This term refers to handheld devices that allow students to respond to questions using the CPS (eInstruction, 2013).

Coordinate Algebra. This term refers to a course in the ninth-grade mathematics curriculum for students in Georgia. The purpose of this course is to formalize and extend mathematics so that the critical areas, organized into units, can deepen and extend understanding of linear relationships (GaDOE, 2016c).

Formative assessment. This term refers to ongoing assessments designed to identify strengths and weaknesses and impact or inform instruction (Georgia Leadership Institute for School Improvement, 2013). Formative assessments are daily informal assessments teachers use to adjust instruction while it is happening.

Georgia Standards of Excellence. The Georgia Standards of Excellence, renamed and revised in 2015 from the Common Core Georgia Performance Standards, are a framework of expectations for K-12 students in various subject areas (GaDOE, 2015). Specific to mathematics, the standards balance procedure knowledge with understanding (GaDOE, 2016c).

Mathematics achievement. This term refers to how well students can complete mastery of state standards. Specific to Coordinate Algebra for this study, students are expected to reason quantitatively, see structure in expressions, create and reason with equations, interpret and build functions, use models, express geometric properties with equations, and interpret categorical and quantitative data (GaDOE, 2016c).

Summative assessment. This term refers to formal assessments administered at key juncture points in a student's education—at the end of a unit or course—to evaluate the extent to which the student has mastered required state standards and related learning goals (Georgia Leadership Institute for School Improvement, 2013).

Purpose of the Study

The purpose of this study was to determine whether using CPS-based mathematics instruction positively affected ninth-grade student achievement. A quasi-experimental quantitative study was conducted to determine whether the implementation of a CPS improved mathematics achievement of ninth-grade students compared to a control group not using the CPS. Because the students were not randomly assigned to the researcher's class, a quasi-experimental approach was appropriate for this study (Creswell, 2012).

Role of the Researcher

The researcher works as a high school mathematics teacher in the public sector of the target school's district. CPSs had been implemented in the researcher's school, yet no study had determined their effectiveness on student achievement. The researcher's role and responsibility in this study were to provide evidence, if any, of differences in mathematics achievement of students who used the CPS compared to the achievement of students not using the CPS.

Chapter 2: Literature Review

Students learn by interacting with their teachers and peers. Teachers need to know the progress and struggles of their students' learning so they can modify instruction to achieve effective teaching and learning. Although numerous teachers embrace the idea of formative assessment, teachers often have trouble assessing student progress and providing effective feedback promptly. A CPS can be used to formatively assess students and provide instant feedback, allowing teachers and students to judge how well students are grasping the learning targets (Morales, 2011).

Hoffman and Goodwin (2006) found that traditional methods of obtaining feedback by using paper-based quizzes and tests allowed teachers to provide no explanation about why the problems were either right or wrong. New technologies, such as a CPS, can assist with that challenge. Cain, Black, and Rohr (2009) found increased levels of student motivation and student engagement with the use of a CPS. Fitch (2004) reported "convincing evidence that interactivity is a critical part of any form of technology-based learning" (p. 72).

Theoretical Framework

According to Horn (2006) and White-Clark et al. (2008), students are better able to store information in long-term memory when they problem solve with subject matter than when they just listen to the teacher. Students may struggle in mathematics classrooms involving a large amount of lecturing, textbooks, and worksheets rather than student-led discoveries and group-based activities. Experimental studies indicated that classes using CPSs showed increased attendance by students as well as positive attitudes (Beekes, 2006; Fitch, 2004).

Theories to support the use of CPSs in the classroom involve differentiated instruction and student engagement. Bailey and Williams-Black (2008) stated that in the past, the main targets of differentiated instruction were the gifted and talented students or special education students, but now regular education teachers incorporate differentiated instruction into lessons to meet the needs of all students. According to Herreid (2006) and Caldwell (2007), a CPS promotes student engagement and active learning. According to Marzano (2010a), a CPS "can have a positive effect on student achievement and can provide diversity in the way that students process new information" (p. 4). In this study, the researcher sought to determine whether using a CPS would also improve ninth-grade students' assessment scores in mathematics.

Differentiated instruction. According to Tomlinson (2004), a differentiated classroom differs from a traditional classroom in many ways. Differentiated instruction is considered to be a collection of the best teaching strategies that support student achievement. To effectively use differentiated instruction, it is essential for teachers to know their students to provide them with knowledge and skills that will improve their learning (GaDOE, 2014). To enhance student learning, differentiated instruction also allows teachers to use various types of student work, such as individual or group work, hands-on or visual learning, or focus on originality. Overall, instruction can be differentiated based on the needs of the students rather than by the teacher's agenda.

Differentiation is a great opportunity to shape a world in which teachers and students share responsibility for making learning work for all participants (Tomlinson, 2004). According to Levy (2008), differentiated instruction is designed to help teachers "meet each child where they are when they enter class and move them forward as far as possible on their educational path” (p. 162). As a result, differentiation can provide every student with an individualized education that offers that student assistance in achieving goals and meeting set standards.

Differentiation permits students to find their excitement by engaging in more profound learning. It also permits students to comprehend at their pace. By differentiating and using the CPS, students often try harder and make attempts to study more difficult information to help understand the learning target better. Students who are very motivated increase their reading skills as they attempt to comprehend and learn during CPS instruction (Bell, 2010).

According to Santangelo and Tomlinson (2012), teachers should accept the responsibility for student achievement in their classroom and recognize the different avenues to success. Some of the problems in implementing differentiated instruction can be overcome with the effective use of technology. Technology can prepare teachers to focus on students’ needs through instructional input, learning activities, and chances to demonstrate understanding. Therefore, the power of technology lies in the teacher’s ability to use it for modifying instruction to meet the needs of all students. Technology also can help teachers to address the ways students demonstrate what they learn.

Earl (2013) stated that differentiated instruction makes sure that “the right students get the right learning tasks at the right time” (p. 95). By not offering students different strategies for learning the curriculum through differentiated instruction and assessment, teachers may lead students to believe that they cannot be taught. Joseph, Thomas, Simonette, and Ramsook (2013) found that, in many schools, teachers teach and evaluate all students in the same way, using the same lesson plans, without focusing on the student discrepancy. Chesley and Jordan (2012) indicated schools should transform current curricula to reflect 21st-century schools. The objective of differentiated instruction is to offer challenging learning experiences to all students to increase student career and college readiness (Santangelo & Tomlinson, 2009). One approach to encouraging teachers to use new techniques is to allow teachers to integrate differentiated instruction into classroom instruction as a critical thinking strategy rather than an instructional strategy (Ireh & Ibeneme, 2010).

Content. Researchers have posited that course content, process, and product allow differentiated instruction to take place by showing student readiness, interest, and learning profile (Joseph et al., 2013; Levy, 2008; Santangelo & Tomlinson, 2009; Tomlinson & Imbeau, 2010). Teachers can respond by differentiating content, which is what the student is learning and where learning takes place. According to Anderson (2007), teachers may choose to differentiate based on student readiness by adjusting the levels of difficulty of the specified course content. Teachers can design tasks very similar to the student's skill level. In math, some students may be ready to work with factoring quadratic expressions when the leading coefficient is 1, whereas other students may be ready to work with factoring quadratic expressions when the leading coefficient is greater than 1. Anderson explained that teachers could decide to differentiate content by providing students with choices to work alone or in groups, to use textbooks, or to use technology as a method for developing comprehension of the course content or concept.

Process. Another method of differentiating instruction is process, which is how the teacher helps the student to learn through classroom instruction and assessments (Joseph et al., 2013). As indicated by Anderson, process differentiation is not only by how the teacher chooses to instruct class but “how the learners come to understand and assimilate facts, concepts, or skills” (p. 50). Some effective process differentiation strategies include higher order thinking skills, open-ended response questions, self-discoveries, and research (Bailey & Williams-Black, 2008).

Addressing students’ interests causes students to be motivated to learn (Tomlinson & Imbeau, 2010). Questions asked prior to introducing a new unit permit teachers to group students in relation to elements of the unit that interest each student. Santangelo and Tomlinson (2009) reported capturing students’ interest by asking students to correlate their interests with the course content unit of study, having students complete surveys, and have students complete exit tickets. Such student input allows teachers to use differentiated instruction aligned with students’ interests, as students are motivated to associate what they learn with what is already important to them.

Another aspect of the process of differentiated instruction is student learning preferences. Student learning preference is based on the senses, resulting in visual, auditory, or kinesthetic learners. Teachers may select different learning styles for various assignments tasks or use a combination of styles (Joseph et al., 2013; Levy, 2008). For example, some students prefer working in silence, whereas others prefer sound; some students prefer a brightly lit environment, whereas some prefer soft lighting; and some students prefer working at a desk, whereas some prefer working at group stations (Anderson, 2007). In addition, students’ gender or culture may affect students’ learning preferences (Levy, 2008; Santangelo & Tomlinson, 2009).

Product. A third approach that teachers can respond by differentiating is product, which is how the student demonstrates learning (Joseph et al., 2013). Differentiated instruction depends on the ongoing use of assessment to collect data about student readiness and interests (Levy, 2008). If teachers have accurate, timely, and reliable data based on what the students know and are able to do, then they can correct their method of teaching to help students learn effectively. Bailey and Williams-Black (2008) proposed product differentiation also lets students choose their own way to prove they comprehended the information that they were taught. Guthrie and Carlin (2004) found that students with language barriers were excited about being able to prove that they understand course content without having to be singled out. Overall, Joseph et al. (2013) suggested differentiated instruction can help enlarge teacher efficacy, help all students excel in the classroom, increase student achievement and motivation, help students become independent thinkers, and bridge connections between students and different course content areas.

Student engagement. According to Tomlinson (2004), students are more likely to succeed when they understand the learning goals and see them as important and personally relevant. Many researchers observed increased student engagement and critical thinking when using CPSs in the mathematics classroom (Horn, 2006; Parsons & Taylor, 2011; Sun, Martinez, & Seli, 2014). D. Johnson and McLeod (2004) stated that no learning will take place if students are not engaged and motivated to learn. According to Cain et al. (2009), modifications in instructional strategies are required to grasp and keep students' attention throughout the lecture, observe students' progress so that any misunderstanding can be instantly corrected, and improve students' grades and enjoyment. Therefore, the goal of using a CPS is for the teacher to engage all students in the class in a positive manner at any point during instructional time. Beekes (2006) implied that interaction is vital to student learning because it encourages students to share their opinions in open discussions. Overall, incorporating CPSs into the class lesson should shift students from being passive learners to engaged learners.

To engage and motivate students, teachers have to be prepared to make learning relevant to the real world. Bell (2010) found that real-world projects deepen learning for students and increase student engagement. The CPS can assist in encouraging students to engage in active learning by staying focused on the class lesson. According to Horn (2006), teachers' guidance, openness, and honesty with the students also increase achievement and engagement in CPS classrooms. Equipping teachers and their classrooms with CPSs should help increase student engagement during instructional time.

Using a CPS in the classroom has reportedly had a positive impact on student engagement and attitudes. Fitch (2004) and Beekes (2006) examined how well students reacted to CPSs, confirmed that students liked using the CPSs, and indicated that CPSs are excellent active learning devices. Students become engaged when their academic experience includes active learning, enrichment activities, teacher–student interaction, or peer collaboration (Carini, Kuh, & Klein, 2006). Many students are more successful when offered several ways to be successful. Beekes discovered that CPSs improve student participation and class discussion. According to Caldwell (2007) and Fies and Marshall (2006), CPSs generally have a positive impact on the classroom.

Many students lack engagement in mathematics because they are asked to learn something they do not care about, they feel they have no voice in their learning, they lack needed skills, and they lack family support (White-Clark et al., 2008). By incorporating a CPS into instruction, students are given the chance to explore different avenues with technology to improve problem solving and higher order thinking skills. When students are engaged in learning, they become involved and more competent in the targeted objectives. Fitch (2004) suggested that interactive learning increases student interest. Therefore, interaction may be the most important feature in using a CPS. Toshalis and Nakkula (2012) stated, "Without engagement, there is no *way* to learn" (p. 33). Based on his classroom experiences, Beekes (2006) concluded that a CPS is beneficial because it causes students to actively participate, permits teachers to assess students' prior knowledge, functions as a tactical approach to present new material, and provides instant feedback.

Penuel et al. (2007) shared some instructional strategies that can be used in classrooms in conjunction with CPSs, including posing "conceptually focused questions, requiring students to answer questions, displaying students' responses for all to see, and engaging students in discussion" (p. 320). If these strategies are implemented on a continuous basis, teachers can promote classroom participation and keep the students' attention. Guthrie and Carlin (2004) reported that when students used their clickers to respond to teachers' questions, student participation reached high levels.

When teachers use CPSs, they should expect students to actively take an interest in class discussions and perform well on assessments. Guthrie and Carlin (2004) reported, on average, about 94% of students engaged in the lesson tried to answer questions using the CPS and their clickers. CPSs can be effective teaching tools if teachers consider the needs of their students and the goals of the class. The CPS also permits teachers to use technology that provides interactive learning (Kaleta & Joosten, 2007). Each student has a clicker in his or her hand that offers student engagement and student interaction.

When used in different subject areas, studies reported positive student-engagement outcomes from using a CPS. Preszler, Dawe, Shuster, and Shuster (2007) reported that 81% of biology students stated use of a CPS and clickers helped to increase their interest. Lincoln (2008) reported that 66% of marketing students responded the use of a CPS helped to keep them attentive during class. About 63% of those same students felt the clickers made the class more enjoyable.

Kaleta and Joosten (2007) reported 94% of teachers observed an increase in student engagement when students used a CPS and clickers. Further, 68% of teachers thought the clickers improved student interaction, and 87% stated using a CPS improved student participation. As a result of using their clickers, 69% of students stated they were more engaged and attentive, and 70% of students responded that using a CPS and clickers increased their class participation (Kaleta & Joosten, 2007). Stagg and Lane (2010) concluded using a CPS is a useful way to effectively engage and assist students with their learning and information literacy.

Cain et al. (2009) suggested that the use of technology like the CPS helps to increase the frequency of student active responses and as well as academic achievement. A CPS used in conjunction with a precise lesson provides effective feedback for teachers but more importantly the students. D. Johnson and McLeod (2004) declared that student motivation and immediate feedback are indications of students' active engagement during instruction. According to Guthrie and Carlin (2004), students indicated effective use of a CPS helped them to learn better. Marzano and Heflebower (2011) stressed that the goal of formative assessments, like the CPS, should be to provide feedback to students and teachers so that teachers can make revisions to improve student achievement.

The use of a CPS can provide teachers with significant data to drive instruction and can assist teachers with assessing students more effectively. Research has indicated students who used CPSs performed better on standardized tests (Caldwell, 2007; Herreid, 2006). In assessing specific content knowledge, Geier et al. (2008) reported students engaged in CPS-based instruction scored better on standardized tests than students who received traditional instruction. According to Haystead and Marzano (2009), more than 300 volunteer teachers conducted studies on the effects of games on student achievement. In these studies, using academic games led to a 20-percentile-point gain in student achievement (Marzano, 2010b). Wolter, Lundeberg, Kang, and Herreid (2011) found that using a CPS increases students' attention and helps with long-term memory storage. Beekes (2006) concluded that a CPS requires students to be actively engaged, allows teachers to assess students' prior knowledge, lets teachers introduce new standards, and allows teachers to provide immediate feedback for student understanding.

Student Motivation

Student motivation studies. Toshalis and Nakkula (2012) declared, "Without motivation, there is no *push* to learn" (p. 33). Although students may master mathematics skills by the traditional approach, many students are not motivated to master math skills based on traditional instruction. Researchers have focused on the "success and effectiveness" of technology in classrooms due to its popularity (Li & Ma, 2010, p. 216). For the most part, students of the 21st century use computer games for learning and entertainment. According to McTighe and O'Connor (2005), a wise teacher will bring such technology into the classroom setting to help motivate students to learn. Guthrie and Carlin (2004) highlighted that ways to improve student motivation include utilizing collaborative learning and a CPS.

For students to believe that they can be successful in learning, they first must be motivated. Black et al. (2004) asserted that effective feedback for students lets them understand learning strategies and problem solving rather than just grades. Using a CPS and receiving feedback that concentrates on what needs to be corrected, all students can be encouraged to believe that they can move forward. Morales (2011) found that receiving feedback from teachers encourages most students to think about the question and choose an answer. Therefore, the most important feature of a CPS is how well a teacher uses it to promote interactive learning and reflection of student learning. Teacher–student interaction and peer collaboration can create a supportive environment in which students investigate their own ideas, hear different ideas from their peers' perspective, and assess those ideas (Black et al., 2004).

Li and Ma (2010) indicated that a shift occurred from using CPSs to support traditional instruction in mathematics classrooms to using CPSs to create interactive learning in student-centered mathematics classrooms. Using a CPS in the classroom creates a positive environment for the teacher and students that causes everyone to feel enthusiastic about the result. Li and Ma credited student academic achievement and motivation to not only the use of technology but also the development of teaching from pedagogical reform. Student collaboration appears to work. Assigned groups utilize their class time effectively to discuss assigned topics and perform at least as well or better than students who receive traditional instruction (Li & Ma, 2010). Students' attitudes are influenced by the degree to which teachers encourage and facilitate peer collaboration while the CPS questions are in progress (Morales, 2011). Li and Ma thoroughly examined teaching mathematics with technology and observed that successful mathematics learning with technology is highly reliant on the teachers' teaching style and the students' ability level.

Bruff (2007) reported that CPSs allow students to interact and learn in a way they are most familiar with: technology. Therefore, the CPS may be used to motivate student collaboration and facilitate individual learning and immediate feedback. Duncan (2006) declared that the greatest teacher can lose students' attention minutes into the class session if that teacher only uses traditional instruction. Student attention can be sustained by applying CPS interaction to keep the students involved. Therefore, CPSs can offer effective and adaptable support for teaching.

Kaleta and Joosten (2007) reported that immediate feedback allows the students to self-check their learning progress for the topic they are learning. About 38% of the students in Kaleta and Joosten's study reported the use of the CPS helped them to make better grades. Preszler et al. (2007) implemented a study that included four lower level and two upper level biology classes at a university. All of the teachers used the CPS along with questions throughout their instruction. Overall, students in the lower level classes showed greater improvement with the use of the CPS than those in the upper level classes. About 70% of the students across all of the six classes concurred that CPSs offered them some assistance with understanding the class material (Preszler et al., 2007).

Research also has suggested that motivated students with positive attitudes toward mathematics show increased achievement (Li & Ma, 2010). Singh, Granville, and Dika (2002) stated highly motivated students who display positive attitudes toward mathematics show improved success as well as achievement levels compared to uninterested students with negative attitudes toward mathematics.

Formative assessments. Cauley and McMillan (2010) stated that formative assessment is an ongoing topic of discussion among teachers and administrators and is identified as an effective method to assist in improving student motivation and achievement. Continuous formative assessments can be done through observations and by asking oral questions presented to students while learning targets are being taught or reviewed. One of Stiggins's (2005) well-known approaches, assessment for learning, presents students with clear learning targets, examples of strong and weak student work, and effective feedback that allows students to set personal learning goals. Using this type of approach lets students know about their daily improvement and their learning in meeting their objectives.

Stiggins and Chappuis (2012) argued that assessments serve "to gather information about student achievement to help teachers make instructional decisions that will enhance learning" and "to motivate students by keeping them in touch with their learning success" (p. 23). Earl (2013) discussed three types of approaches to classroom assessment: assessment for learning, assessment as learning, and assessment of learning. Assessment for learning is designed to give teachers insight on students' thinking in order to differentiate instruction. Assessment as learning occurs when students take ownership of their learning by becoming independent thinkers. Assessment of learning allows teachers to see what students know and decisions in the form of summative assessments.

Stiggins (2005) also observed that when students have clear learning targets and receive continuous feedback, students have support for understanding what they are learning, setting goals, and self-evaluating. Formative assessments place importance on modified teaching and student improvement, which supports student motivation and allows students to retain engagement and achievement (Cauley & McMillan, 2010). Therefore, formative assessments, effective feedback, and continuous remediation can be great methods to improve student motivation and achievement. The CPS is a form of formative assessment providing immediate feedback.

Use of the CPS

Student achievement and CPS. CPSs provide teachers with the ability to easily assess student achievement and actively engage students. A CPS also can assist teachers in assessing students' knowledge before and after class discussion. Cauley and McMillan (2010) found, "When students focus on improvement and progress, they are more likely to adopt mastery goals and develop high self-efficacy and expectations for success" (p. 5). Even though the effectiveness of a CPS depends largely on instructional strategies, use of a CPS helps to increase classroom interactions (Wolter et al., 2011).

White-Clark et al. (2008) perceived a need for more effective instructional resources and sound curricula to assist in improving mathematics achievement. Using computer-based programs in classrooms may help to improve mathematics achievement and close the gap between high- and low-level learners (Rothstein & Jacobsen, 2006). How teachers use any type of technology can determine if students receive positive, negative, or neutral results from working with computers in the classroom (Wenglinsky, 2005). Because students learn concepts in different ways and at different paces, teachers need to use different strategies to teach mathematics to diverse students. Therefore, teachers should continue to look for ways to differentiate instruction, increase motivation, and improve attitudes towards mathematics.

According to Bell (2010), using a CPS is a key strategy for developing independent thinkers and learners. During the process, students can become successful in learning by using this motivating approach and achieve valuable skills to prepare them for their future. Herreid (2006) stated, "Courses with active learning strategies were far superior in producing learning gains than traditional lectures" (p. 43).

CPSs could change the teaching methods for teachers. The CPS gives all students in the classroom an equal opportunity to become active learners, encourages students to actively participate in peer discussions, and gives teachers a chance to provide instant feedback (Trees & Jackson, 2007). Cain et al. (2009) reported students indicated that the immediate feedback from the CPS helped them to understand the learning objectives more effectively. Overall, a CPS creates more interactive, student-centered classrooms.

Students learn about themselves when they are encouraged to think and make their own learning choices. Once students find out that they can learn from their mistakes, they can see that as part of the learning process. When teachers put a CPS into practice, they let students discover their individual learning abilities. Students are required to think and make better choices, allowing them to become independent thinkers and in charge of their learning (Bell, 2010).

K. Johnson and Lillis (2010) pointed out that the use of a CPS in a microbiology class improved students' motivation and attention span and provided instant feedback concerning the students' comprehension of the learning target. Students agreed that the clickers helped them to stay alert, to confirm that they comprehended the information, and to learn the standards more successfully. MacGeorge et al. (2008) observed that CPSs are effective devices for keeping students engaged in active learning during classroom instruction, improving students' communication skills, and offering teachers assistance with creating a more student-centered classroom. Fies and Marshall (2006) found that the most frequently listed student benefits of a CPS are improved participation and attendance as well as improved classroom interaction, engagement, and enjoyment.

Motivation and CPS. Heaslip, Donovan, and Cullen (2014) found that students became more engaged when a CPS was used in the classroom. The use of a CPS helps to motivate students to participate in short discussions and to increase their attention in class (Herreid, 2006). Caldwell (2007) and Fies and Marshall (2006) also found that the use of a CPS increases learning, interactivity, attendance, and enjoyment. Trees and Jackson (2007) reported that CPSs help students to be less lethargic, to interact more with peers, and to be more focused during class.

When using a CPS, every student in the class can answer an oral question posed by the teacher as opposed to being in a traditional class setting where only one student is called upon to answer. In an analysis of 66 studies, Keough (2012) identified eight general student outcomes for using clickers in the classroom; attention span, participation, and feedback are most important to the researcher. In 35% of the studies, the students' attention span showed high levels of improvement by using clickers. In 29% of the studies, using clickers improved student participation. Further, in 18% of the studies, student reported clickers provided effective feedback from teachers.

Through the use of a CPS, students may play an active role in the classroom by increasing their motivation and engagement (Terrion & Aceti, 2012). According to Cain et al. (2009), teacher–student interactions improved due to using a CPS, resulting in less classroom disruption and more active, engaged learning. Hoffman and Goodwin (2006) concluded that using a CPS is a step forward to improve the quality of instruction. In essence, a CPS can help to improve student comprehension, quiz scores, test scores, and student interaction.

Guthrie and Carlin (2004) found that when students are engaged in an instructional lesson, they are motivated to stay focused on learning. Students who appear to be unconcerned about being in class may want the teacher to interact with them in ways that are meaningful to them. Students are active learners, so finding the ideal instructional aides to assist in connecting learning is important. Therefore, a CPS can be the avenue for students to become actively engaged in their learning. Students who are actively engaged in class are attentive, participate, and are motivated to learn.

Caldwell (2007) posited that a CPS can be used to conduct experiments and to motivate student learning. The use of a CPS can motivate students to respond on their own while also supplying group rewards for responding to questions as a team. The CPS also can provide a detailed record of student or group performance. Therefore, group rewards can help to enhance individual motivation because the students will want to contribute to the group's overall academic success.

According to Bell (2010), the CPS helps to enhance students' social learning skills as they practice 21st-century communication and collaboration skills. Students are then able to learn the essential skills of effective communication, mutual respect, and collaboration while brainstorming together. When using their clickers, students learn to be responsible for meeting their daily goal of the learning target. When student collaboration takes place, all of the students are expected to have some input. Bell noted that when the students are held accountable to other students as well as the teacher, student show more motivation. In essence, students prefer not to disappoint their classmates.

Levy (2008) affirmed that learning is significant only when students recognize its importance. Therefore, once the learning targets have been created, the teachers must deliver the standards in a way that will motivate the students. Overall, students should view learning as a preparation tool that will allow them to understand and apply their knowledge in the real world. Generally speaking, the use of CPSs can increase peer collaboration, teacher–student interaction, and student engagement in class discussions; improve students' comprehension, learning, and achievement; provide immediate feedback; and promote a student-friendly atmosphere in the classroom (Bojinova & Oigara, 2011).

Strengths and weaknesses. Lincoln (2008) observed that CPSs keep the students' attention, provide instant feedback, take attendance, and reduce grading. In reference to immediate feedback, the CPS allows students to see the class results and to see how their answers compare with their peers. Also, the CPS allows the teacher to easily see the students' progress in relation to the learning targets. If the majority of the class answers the question incorrectly, the teacher quickly can recognize the need to reteach that particular part of the standard. If students answer the question correctly, the teacher can advance to a new learning target. In essence, the main benefit of using a CPS is that it provides a general idea of where the class stands as a whole during instruction.

Another key reason to having CPSs in classrooms is they help support teacher–student interaction. Traditional lecture-based classroom instruction makes engaging all students difficult. Traditional classroom teachers try to include students by quizzing them with different methods such as raising hands, calling on individual students, or trying small-group discussions. The disadvantage of using these strategies is not being able to keep the students anonymous. When the method used in class does not allow the students to remain anonymous, the students are shown to feel uncomfortable using those methods. (Hoffman & Goodwin, 2006). This anonymity is particularly appealing to struggling students or English language learners (Guthrie & Carlin, 2004).

Kaleta and Joosten (2007) identified three significant drawbacks for using CPSs in the classroom: time, technical support, and the learning phase. The first drawback is time. Teachers must devote additional time not only to organize the questions, but also to fit those questions into their usual daily instruction. Teachers in Kaleta and Joosten's study discovered that they were not able to have as many class discussions as usual, because the CPS took too much time to go into detail on new learning targets. The second drawback is technical support. Teachers have to deal with broken, lost, or defective clickers; technology problems take away class time and often cannot be corrected by teachers. The third drawback is the learning phase. Use of the CPS requires time initially for teachers and students to become familiar and comfortable with the CPS.

Research Questions

This quantitative study was guided by two research questions:

1. Will the implementation of CPS-based instruction result in a statistically significant improvement in the mathematics achievement of ninth-grade Coordinate Algebra students as measured by benchmark assessments?

2. Will the implementation of CPS-based instruction result in a statistically significant improvement in the mathematics achievement of ninth-grade Coordinate

Algebra students as measured by a midterm Progress Report and final Report Card?

Chapter 3: Methodology

The purpose of this study was to determine whether using CPS-based mathematics instruction positively affected achievement of ninth-grade students in Coordinate Algebra classes. This chapter presents the participants, instruments, data analysis, and procedures of this quantitative study.

Participants

The research participants for this study were ninth-grade students in the researcher's class. A total of 75 students participated in the study. The treatment group was 42 students who used a CPS during instruction; the control group was 33 students who did not use a CPS. The students in the researcher's four Coordinate Algebra classes represented regular education students, students with disabilities, and English language learners. The treatment group consisted of two ninth-grade Coordinate Algebra classes that included 22 African American students, 18 European American students, one multiracial student, and one Hispanic student. The control group consisted of two ninth-grade Coordinate Algebra classes that included 17 European American students and 16 African American students. All students in this study were between the ages of 14 and 17 years old. The researcher has a specialist's degree in curriculum and instruction and 12 years of teaching experience.

Instruments

The instruments used for data collection were benchmark assessments given at Weeks 1, 4, 6, and 9 of the 9-week period; the midterm Progress Report; and the final Report Card for the 9-week period. Data from benchmark assessments were used to answer Research Question 1. Data from the Progress Report and summative Report Card were used to answer Research Question 2.

Benchmarks. The benchmark assessments were designed by the researcher from a collection of questions published by Carnegie Learning (Snyder & Metz, 2012) in Coordinate Algebra textbooks and workbooks. Carnegie Learning designs all assessments to meet the Georgia state standards in mathematics and related curricula. According to Creswell (2012), the goal of good research is to have measures that are reliable or consistent. To determine reliability of the assessments, Carnegie Learning uses the alternate-forms and test-retest reliability approach (Creswell, 2012). The validity of a test implies that researchers can develop "reliable evidence to demonstrate that the interpretation of scores matches its intended use" (Creswell, 2012, p. 159).

Benchmark assessments included a pretest, interim midterm assessment, and posttest. The pretest benchmark assessment (see Appendix A) was given at the beginning of the term. The posttest benchmark assessment (Appendix B) was administered at the end of the term. A comparison between the pretest and posttest served to answer Research Question 1. The interim benchmark assessment (Appendix C) was administered twice, at Weeks 4 and 6, to determine any change in scores in the middle of the term, also to answer Research Question 1. The change in scores was compared between the treatment and control groups.

Quarterly reports. The researcher's school uses Infinite Campus, an online teacher grade book, to generate quarterly reports. Students receive progress reports halfway during every 9-week grading period as well as a report card at the end of every 9 weeks. The midperiod quarterly report, the Progress Report, served as an interim assessment. The final quarterly report at the end of the grading period, the Report Card, represented a summative assessment and was used as a posttest to answer Research Question 2. The change in scores was compared between the treatment and control groups.

Procedures

Design. A quasi-experimental quantitative study was conducted in order to determine whether the implementation of a CPS would improve mathematics achievement of ninth-grade students. Because the students were not randomly assigned to the researcher's class, a quasi-experimental approach was appropriate for this study (Creswell, 2012).

The researcher's classroom was equipped with a CPS, a ceiling-mounted LCD projector, a SMART board, and a desktop computer. Due to prior training with the use of the CPS, the researcher did not need additional training. Before the implementation of this study could take place, the researcher trained the treatment group on the use of the CPS by providing them with a general review and a hands-on demonstration of how to use the handheld devices to answer the questions.

At the beginning of the 9-week study, the students in the treatment group received a unique identification number to be used in conjunction with handheld devices. The students in the two control-group classes continued to receive traditional instruction without the use of a CPS. The instructional approach, a CPS, was the independent variable. The CPS was tested to determine if it would have an impact on student mathematics achievement, the dependent variable.

Before the study began, the experimental and control groups took the pretest benchmark assessment (see Appendix A). Other than the CPS, the treatment and control groups had access to identical learning materials, including the researcher's PowerPoint slides, textbooks, learning targets, and formative assessments. During the middle of the study, both groups took a formative, interim benchmark assessment (Appendix C) at Weeks 4 and 6 to assess their learning. Throughout this study, the students completed self-assessments. Students in the treatment group received immediate feedback through the CPS. Halfway through the 9-week period, all students received a quarterly Progress Report score. At the end of the study, students took the posttest benchmark assessment (Appendix B). Also at the end of the term, all students received a summative Report Card.

The researcher collected and compared data from the pretest benchmark assessment in Week 1 to the posttest benchmark in Week 9 to answer Research Question 1. Also to answer Research Question 1, scores on the Week 4 and Week 6 administrations of the interim benchmark assessment were compared. Scores from the midterm Progress Report and final Report Card were compared to answer Research Question 2.

Data analysis. Statistical analysis was performed using SPSS to analyze the benchmark scores and grade reports of the treatment and control groups. Descriptive statistics used in this analysis included measures of central tendency and variability. It was important to show that the scores of the students in the treatment and control groups were not statistically significantly different on the pretest benchmark assessment completed before the implementation of the CPS. Then the scores of the treatment and control groups on the remaining benchmark assessments could be compared.

Chapter 4: Results

The purpose of this study was to determine if the use of CPS-based mathematics instruction had a positive effect on mathematics achievement of ninth-grade students in Coordinate Algebra courses. Data collected for this study were compared between students who received CPS-based instruction, the treatment group, and students who received traditional mathematics instruction without the use of a CPS, the control group.

This chapter is organized into four sections: sample demographics, results for Research Questions 1 and 2, and a summary of the results. The data collection instruments used to determine the effectiveness of CPS-based instruction for ninth-grade mathematics were benchmark assessments and quarterly grade reports. Three benchmarks were designed by the researcher from a collection of questions published by Carnegie Learning (Snyder & Metz, 2012) in Coordinate Algebra textbooks and workbooks: a pretest, an interim midterm assessment, and a posttest.

Sample Demographics

This study took place at a public high school in rural, central Georgia. The two groups of students who participated in this study were enrolled in the researcher’s mathematics classes. Participants were in four ninth-grade Coordinate Algebra classes, divided into treatment and control groups (two classes each). The demographic characteristics of these two groups highly resembled that of the school and are shown in Table 1.

Results for Research Question 1

Will the implementation of CPS-based instruction result in a statistically significant improvement in the mathematics achievement of ninth-grade Coordinate

Algebra students as measured by benchmark assessments? First, scores on a pretest benchmark assessment (Appendix A) administered Week 1 were compared to scores on a posttest benchmark assessment (Appendix B) administered Week 9. As an additional formative assessment, scores on the interim benchmark assessment (Appendix C) were compared between Week 4 and Week 6; the same test was administered both times.

Table 1

Frequency Demographics of Sample

Demographic	Treatment group (n = 42)	Control group (n = 33)	Total (N = 75)
Gender			
Male	22	18	40
Female	20	15	35
Ethnicity			
African American	22	17	39
European American	18	16	34
Hispanic	1	0	1
Multiracial	1	0	1

Pretest analysis. First, pretest benchmark assessment scores were compared between treatment (M = 72) and control (M = 76.09) groups. The difference was not significant, $t(73) = -1.10$, $p = .137$.

Pre- and posttest analysis. Means, standard deviations, and standard error of the means for the two groups are displayed in Table 2. As shown in Table 2, pretest benchmark assessment scores for the treatment group ($M = 72$, $SD = 16.8$) were compared to posttest benchmark assessment scores ($M = 77.93$, $SD = 8.93$), and the scores showed significant improvement, $t(42) = -2.35$, $p = .02$. Students who used a CPS to guide mathematics instruction made significant gains in learning about linear and exponential functions.

Table 2 also shows the comparisons of the pretest and posttest means and standard deviations for the control group, who received traditional instruction. Students' pretest scores for the control group (*M* = 76.09, *SD* = 14.88) were compared to posttest scores (*M* = 80.52, *SD* = 9.23). For the control group, posttest scores were not statistically significantly different from pretest scores, *t*(33) = -1.46, *p* = .08.

Table 2

Descriptive Statistics and t-Test Results for Pretest and Posttest Benchmark Assessment Scores

	Descriptive statistics			Comparison of means	
Group	*M*	*SD*	*SEM*	*t*	*p*
Treatment (*n* = 42)				-2.35	.02
Pretest Week 1	72.00	16.80	2.59		
Posttest Week 9	77.93	8.93	1.38		
Control (*n* = 33)				-1.46	.08
Pretest Week 1	76.09	14.88	2.59		
Posttest Week 9	80.52	9.23	1.61		

Students in the treatment group showed a mean score increase of 3.96, whereas students in the control group showed a mean increase of 3.99. The difference between groups was not statistically significant, *t*(75) = 0.38, *p* = .70. This result shows that there was not a statistically significant difference in the test score gains made by students in the treatment and control groups. The Cohen's *d* calculator was used to find the effect size of the difference in test scores. The treatment (use of CPS) had a small effect (*d* = 0.29).

Interim benchmark assessments. The same interim benchmark assessment was given to all students on Weeks 4 and 6 as a formative assessment. Descriptive statistics of the interim formative assessments from the treatment and control groups are displayed in Table 3. According to the results, the students using a CPS performed statistically significantly better on the Week 6 benchmark assessment than on the Week 4 benchmark assessment, showing a mean increase of 9.26 points, $t(42) = -3.12$, $p = .003$. Control-group students showed a mean increase of 5.12 points between the Week 4 and Week 6 benchmark assessments, which was not a statistically significant difference.

Table 3

Descriptive Statistics and t-Test Results for Interim Benchmark Assessments

	Descriptive statistics				Comparison of means		
Group	*M*	*SD*	*SEM*	95% confidence interval	*t*	*df*	*p* (2-tailed)
Treatment (*n* = 42)					-3.12	41	.003
Interim Week 4	74.79	16.98	2.62	[69.50, 80.08]			
Interim Week 6	84.05	9.11	1.41	[71.96, 81.21]			
Control (*n* = 33)					-1.66	32	.107
Interim Week 4	77.21	14.80	2.58	[78.13, 82.46]			
Interim Week 6	82.33	11.84	2.06	[80.08, 86.53]			

Results for Research Question 2

Will the implementation of a CPS result in a statistically significant improvement in mathematics achievement of ninth-grade Coordinate Algebra students as measured by a midterm Progress Report and final Report Card? Descriptive statistics of quarterly report scores were compared for both groups to determine if the use of a CPS significantly improved mathematics achievement based on Progress Report grade scores from halfway through the 9-week period and final Report Card grade scores. The treatment group increased mean scores by 2.58 points; the control group increased mean scores by 2.64 points. Table 4 shows that the use of a CPS resulted in no statistically significant difference between the Progress Report scores and the Report Card scores for either group.

Table 4

Descriptive Statistics and t-Test Results for Quarterly Report Scores

	Descriptive statistics				Comparison of means	
Group	*M*	*SD*	*SEM*	95% confidence interval	*t*	*p* (2-tailed)
Treatment (*n* = 42)					-1.33	.19
Progress Report	82.02	8.94	1.38	[79.23, 84.81]		
Final Report Card	84.60	10.07	1.55	[81.46. 87.74]		
Control (*n* = 33)					-0.94	.35
Progress Report	79.00	10.45	1.82	[75.29, 82.71]		
Final Report Card	81.64	10.86	1.89	[77.79, -85.49]		

Summary

The analysis of data collected in this study was used to determine whether CPS-based instruction statistically significantly improved the student achievement of ninth-grade Coordinate Algebra students as measured by benchmark assessments and quarterly reports. The results showed that a CPS could result in statistically significant improvement in student achievement as measured by benchmark assessments. However, there was no statistically significant difference in improvement of student achievement when the treatment group was compared to the control group.

Chapter 5: Discussion

Overview of Applied Dissertation

To determine whether the implementation of a CPS would improve mathematics achievement of ninth-grade students, the researcher created a quasi-experimental study that included collecting and analyzing quantitative data (Creswell, 2012). The study was conducted at a public high school in rural, central Georgia and included 75 ninth-grade Coordinate Algebra students, of whom 42 students were in the treatment group and 33 in the control group. Students in the treatment classes used a CPS; those in the control group received identical instruction but without the CPS. A CPS is a system used as a supplementary technology resource in the researcher’s classroom. Students use handheld devices to respond to questions; aggregated, anonymous responses are shown on a screen, prompting classroom discussion. Descriptive statistics and summaries were used to estimate the impact on student and mathematics achievement.

Previous research suggested use of a CPS would increase student engagement and test scores. Caldwell (2007) showed that the use of a CPS increased student achievement. Beekes (2006) found that students were more engaged in learning with CPSs. Prensky (2008) defended the integration of technology into the classroom by asserting that more student interaction should take place in 21st-century classrooms rather than the traditional lecture-based instruction.

This chapter is organized into five sections. First, findings are summarized. Then, implications of findings and relevance to the literature are discussed, followed by limitations of the study, recommendations for further research, and conclusion. Two research questions were established to guide this study:

1. Will the implementation of a CPS result in a statistically significant improvement in mathematics achievement of ninth-grade Coordinate Algebra students as measured by benchmark assessments?

2. Will the implementation of a CPS result in a statistically significant improvement in mathematics achievement of ninth-grade Coordinate Algebra students as measured by a midterm Progress Report and final Report Card?

Summary of Findings

This researcher explored the effects of integrating a CPS into mathematics instruction on achievement of ninth-grade Coordinate Algebra students. Students using the CPS showed statistically significant improvement on benchmark assessments, whereas the control group did not. Yet, the researcher determined that the changes in score on benchmark assessments and quarterly report scores of the treatment and control groups were not statistically significantly different.

Research Question 1. Will the implementation of a CPS result in a statistically significant improvement in the mathematics achievement of ninth-grade Coordinate Algebra students as measured by benchmark assessments? Students in the treatment group who used the CPS showed significant improvement on the posttest benchmark assessment given in Week 9 compared to the pretest Week 1. Mean scores increased by 3.96 points, $t(42) = -2.35$, $p = .02$. Students in the control group increased mean scores by 3.99 points, but the change was not statistically significant. A comparison of the change in mean scores from pre- to posttest between the treatment and control groups revealed no statistically significant difference.

Similarly, analysis of the benchmark assessment given Week 4 and Week 6 to all students showed students using the CPS increased mean scores statistically significantly, by 9.26 points, $t(42) = -3.12$, $p = .003$. Students in the control group showed a mean increase of 5.12 points between the Week 4 and Week 6 benchmark assessments, which was not a statistically significant difference. Again, comparison of the change in mean scores from the Week 4 and Week 6 interim assessments between the treatment and control groups revealed no statistically significant difference.

Research Question 2. Will the implementation of a CPS result in a statistically significant improvement in mathematics achievement of ninth-grade Coordinate Algebra students as measured by a midterm Progress Report and final Report Card? Descriptive statistics of quarterly report scores were compared for both groups to determine if the use of a CPS significantly improved mathematics achievement based on Progress Report grade scores from halfway through the 9-week period and final Report Card grade scores. The treatment group increased mean scores by 2.58 points; the control group increased mean scores by 2.64 points. Neither group showed significant improvement. Use of a CPS resulted in no statistically significant difference.

Implications of Findings and Relevance to Literature

This study adds to the current research by including a quantitative study to determine the impact of a CPS on mathematics achievement of ninth-grade Coordinate Algebra students. Most research associated with a CPS has been done at the postsecondary level and excluded differentiated instruction as an instructional approach (Kaleta & Joosten, 2007; Levy, 2008; Santangelo & Tomlinson, 2009). Researchers have analyzed teachers' and students' perceptions on the use of CPSs and compared student achievement in classrooms that use CPSs with those using traditional instruction

(Santangelo & Tomlinson, 2009; Terrion & Aceti, 2012; Wolter et al., 2011).

Although the results of this study showed ninth-grade students using the CPS increased benchmark assessment scores significantly, the increase when compared to that of a control group was not significant. This contradicts previous research. However, previous research has been conducted at the postsecondary level. For example, Kaleta and Joosten (2007) found using a CPS at the postsecondary level produced higher student grades. Santangelo and Tomlinson's (2009) research, also at the postsecondary level, showed students welcomed the use of CPSs, and the devices enhanced their learning. Cain et al. (2009) declared that college students' attention span increased with the integration of technology such as CPSs. Duncan (2006), Fitch (2004), and Hoffman and Goodwin (2006) cited positive effects of clickers with university students. Beekes (2006) reported positive attitudes with student response systems like the CPS—with postgraduate students. Clearly more research is needed with high school students to determine the impact of CPS use.

Further, this study confirmed the need to consider factors, such as student responsibility and instructional strategies, that could impact students' mathematics achievement. Because of its rapid increase, diversity in classrooms presents a critical challenge to educators, policy makers, and stakeholders to research applicable instructional models that support learning, such as use of CPSs.

Technology increasingly is being integrated into classrooms. Caldwell (2007) asserted that CPSs are the driving forces to teaching with technology in the classroom. According to Bell (2010), integrating such technology in the educational arena is necessary because it is the instrument for improving student achievement and for preparing 21st-century students to be technology savvy. However, the results of this study were consistent with the findings of Kay and LeSage (2009) and Wang et al. (2014), which showed that the use of CPSs was not helpful in improving student achievement. They found that students who utilized technology regularly were engaged but did not perform any better than students who used pencil, paper, and textbooks.

Horn (2006) asserted that constructivism is the best approach for teachers to provide instruction and students to be engaged in their learning. Constructivism involves interaction with the environment and other learners, leading to the students' active involvement in learning. The findings in this study uphold using the constructivist approach in mathematics classrooms to improve student achievement. The researcher observed the active engagement of the ninth graders in this study using the CPS. Students who received CPS-based mathematics instruction to help drive their learning were actively engaged when compared to the students who received mathematics instruction in a traditional manner. The results of this study support the use of constructivism with technology integration. Constructivism gives a useful framework for utilizing technology in creative and motivating ways (Horn, 2006). Using CPSs in classrooms can lead teachers to use more technology to assist with constructivist related lessons.

White-Clark et al. (2008) asserted that a lack of student engagement may be a primary reason for poor performance and motivation in the mathematics classroom. Using a CPS might be interesting enough to gain the attention of all students, including English language learners, unwilling learners, and disengaged students. Overall, incorporating CPSs into the class lesson should shift students from being passive learners to engaged learners. Students become engaged when their academic experience includes interaction (Carini et al., 2006).

Interaction may be the most important feature in using a CPS. Even though the effectiveness of a CPS depends largely on instructional strategies, use of a CPS helps to increase classroom interactions (Wolter et al., 2011). Fitch (2004) reported "convincing evidence that interactivity is a critical part of any form of technology-based learning" (p. 72). Beekes (2006) implied that interaction is vital to student learning because it encourages students to share their opinions in open discussions.

Although this study did not find significant differences in student achievement on tests after use of the CPS, the use of the CPS promoted classroom interaction. Pellegrino and Quellmalz (2010) determined that integrating technology in class instruction and assignments enables teachers to become facilitators while the students take charge of their own learning. Parsons and Taylor (2011) indicated that students take charge of their own learning when using differentiated instruction, and student engagement increases during the process. Joseph et al. (2013) described effective teachers as coaching students to become independent thinkers and learners.

Use of the CPS also promoted continual formative assessment. The CPS provides an easy way to track student progress. Assessment for learning is designed to give teachers insight on students' thinking in order to differentiate instruction (Earl, 2013). Differentiated instruction depends on the ongoing use of assessment to collect data about student readiness and interests (Levy, 2008). If teachers have accurate, timely, and reliable data based on what the students know and are able to do, then they can correct their method of teaching to help students learn effectively.

Limitations of the Study

The researcher recognized limitations during the implementation of this study. One major limitation of this study was the sample size. A small sample size was chosen because of the expected number of Coordinate Algebra courses that the researcher would teach. Also, the sample size was limited to ninth-grade students enrolled in the researcher's four Coordinate Algebra classes, which consisted of 75 students. A larger sample size might have given more precise outcomes.

A second limitation was the number of schools and courses in the study. This study was limited to one high school within the district and did not include the other high school mathematics courses such as Analytic Geometry, Advanced Algebra, Pre-Calculus, Calculus, and Statistics.

A third limitation was attendance. There was no way to control the attendance of the teacher or the students. There was no guarantee that the teachers and students would attend class daily during this research study. Some students in the study missed more days than others. The researcher included make-up days for students who were absent on test days.

A fourth limitation was the set time frame made available for the implementation of this study. The study was limited to one 9-week period, which might have been insufficient to show the impact of a new learning strategy.

A fifth limitation was technology problems that could not be overlooked. Internet issues kept the CPS from working properly at times. Some students had issues with their clickers not responding to the CPS.

Recommendations for Further Research

The results of this study lead to recommendations for possible future research. As noted, this study was designed to fill the gap in the research related to CPS use with secondary-level students. More research is needed with high school students. Most of the literature reviewed for this study involved university students.

Larger sample sizes should be used to produce more precise results. A proposal for future research is to use a larger sample size, possibly in a comparison between different school districts from high school mathematics classes.

Instruments other than those used in this study should be used to decide the impact of CPSs in mathematics classrooms. For this study, benchmarks and quarterly reports were used to determine whether a CPS could improve student achievement. The researcher recommends conducting a study on how CPSs affect student achievement on the Georgia Milestones End-Of-Course assessments. More research is needed to determine the impact that CPSs have on mathematics achievement based on standardized scores such as those on the End-Of-Course assessments.

The 9-week period was too brief to determine the advantages of an instructional model. A study with a longer time frame may produce a more detailed record of how CPSs affect mathematics achievement. Future research should administer yearlong studies on the use of CPSs in mathematics classrooms. A study with an extended implementation period could improve validity and reliability of the results.

Current research on the students' views of CPSs in mathematics classroom is missing. This study focused on student achievement on tests, but a study including assessments of attitudes toward mathematics might yield interesting results.

An objective for future research should be to increase useful, continuous professional development for teachers to increase students' mathematics scores and End-of-Course mathematics assessment scores. Overall, additional research is needed to examine the impact of integrating CPSs and differentiated instruction into ninth-grade mathematics classrooms. Therefore, a future study with more emphasis on activating differentiated instruction in discovering ways to meet the different needs of mathematics students is recommended.

Conclusion

The findings of this study showed mixed results in relation to the impact of CPS-based instruction on mathematics achievement. Using the CPS resulted in significant increases in benchmark scores but not report card scores; further, the increase in scores was not statistically significantly different between the treatment and control group. However, this research is an initial step in studying the use of CPSs with high school students; most of the research has investigated the use of CPSs at the college level.

References

Anderson, K. (2007). Differentiating instruction to include all students. *Preventing School Failure, 51*(3), 49-54. doi:10.3200/PSFL.51.3.49-54

Bailey, J., & Williams-Black, T. (2008). Differentiated instruction: Three teachers' perspectives. *College Reading Association Yearbook, 29*, 133-151.

Beekes, W. (2006). The "millionaire" method for encouraging participation. *Active Learning in Higher Education, 7*(1), 25-36. doi:10.1177/1469787406061143

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House, 83,* 39-43. doi:10.1080/00098650903505415

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2004). Working inside the black box: Assessment for learning in the classroom. *Phi Delta Kappan, 86*(1), 9-21. doi:10.1177/003172170408600105

Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., & Sese, F. (2013). Using clickers in class: The role of interactivity, active collaborative learning and engagement in learning performance. *Computers & Education, 62*, 102-110. doi:10.1016/j .compedu.2012.10.019

Boaler, J. (2006). Urban success: A multidimensional mathematics approach with equitable outcomes. *Phi Delta Kappan, 87,* 364-369. doi:10.1177 /003172170608700507

Bojinova, E., & Oigara, J. (2011). Teaching and learning with clickers: Are clickers good for students? *Interdisciplinary Journal of E-Learning & Learning Objects, 7,* 169-184.

Bruff, D. (2007). Clickers: A classroom innovation. *National Education Association*

Advocate, *25*(1), 5-8.

Byrd, G., Coleman, S., & Werneth, C. (2004). Exploring the universe together: Cooperative quizzes with and without a classroom performance system in Astronomy 101. *Astronomy Education Review, 3*(1), 26-30. doi:10.3847 /AER2004004

Cain, J., Black, E. P., & Rohr, J. (2009). An audience response system strategy to improve student motivation, attention, and feedback. *American Journal of Pharmaceutical Education, 73*(2). Retrieved from https://www.ncbi.nlm .nih.gov/pmc/articles/PMC2690899/

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best practice tips. *CBE Life Sciences Education, 6*(1), 9-20. doi:10.1187/cbe.06-12-0205

Carini, R. M., Kuh, G. D., & Klein, S. P. (2006). Student engagement and student learning: Testing the linkages. *Research in Higher Education, 47*(1), 1-32. doi:10 .1007/s11162-005-8150-9

Cauley, K. M., & McMillan, J. H. (2010). Formative assessment techniques to support student motivation and achievement. *The Clearing House, 83*, 1-6. doi:10.1080 /00098650903267784

Chesley, G. M., & Jordan, J. (2012). What's missing from teacher prep. *Educational Leadership*, *69*(8), 41-45. Retrieved from http://www.ascd.org/publications /educational-leadership/may12/vol69/num08/What's-Missing-from-Teacher -Prep.aspx

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Upper Saddle River, NJ: Pearson.

Duncan, D. (2006). Clickers: A new teaching aid with exceptional promise. *Astronomy Education Review, 5*(1), 70-88. doi:10.3847/AER2006005

Earl, L. M. (2013). *Assessment as learning: Using classroom assessment to maximize student learning* (2nd ed.). Thousand Oaks, CA: Corwin Press.

eInstruction. (2013). *Student response systems.* Retrieved from http://www.einstruction .com/products/student-response-systems

Fies, C., & Marshall, J. (2006). Classroom response systems: A review of the literature. *Journal of Science Education & Technology, 15*, 101-109. doi:10.1007/s10956 -006-0360-1

Fitch, J. L. (2004). Student feedback in the college classroom: A technology solution. *Educational Technology, Research and Development, 52*(1), 71-81. doi:10.1007 /BF02504773

Geier, R., Blumenfeld, P., Marx, R., Krajcik, J., Fishman, B., Soloway, E., & Clay-Chambers, J. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. *Journal of Research in Science Teaching, 45*, 922-939. doi:10.1002/tea.20248

Gely, R., & Caron, P. L. (2004). Taking back the law school classroom: Using technology to foster active student learning. *Journal of Legal Education, 54*(4), 551-569. Retrieved from https://scholarship.law.missouri.edu/cgi/viewcontent .cgi?article=1215&context=facpubs

Georgia Department of Education. (2014). *Teacher assessment on Performance Standard 4: Differentiated instruction.* Retrieved from http://www.gadoe.org/School -Improvement/Teacher-and-Leader-Effectiveness/Documents/FY15 TKES and

LKES Documents/QG TAPS 4 Differentiated Instruction 2014-15.pdf

Georgia Department of Education. (2015). *Georgia Standards of Excellence (GSE).* Retrieved from https://www.georgiastandards.org/Georgia-Standards/Pages /default.aspx

Georgia Department of Education. (2016a). *Georgia Department of Education, free and reduced price meal eligibility, October 6, 2015 (FY2016-1)* [Database]. Retrieved from https://app3.doe.k12.ga.us/ows-bin/owa/fte_pack_frl001_public.entry_form

Georgia Department of Education. (2016b). *Georgia Department of Education, enrollment by ethnicity/race, gender, and grade level, (PK–12), March 3, 2016 (FTE 2016-3)* [Database]. Retrieved from https://app3.doe.k12.ga.us/ows-bin /owa/fte_pack_ethnicsex.entry_form

Georgia Department of Education. (2016c). *Georgia Standards of Excellence: Mathematics.* Retrieved from https://www.georgiastandards.org/Georgia -Standards/Frameworks/Coordinate-Algebra-Standards.pdf

Georgia Leadership Institute for School Improvement. (2013). *Leading a team to develop benchmark assessments: A performance-based learning module for Georgia's educational leaders.* Retrieved from http://www.glisi.org

Green, J., Liem, G., Martin, A., Colmar, S. Marsh, H., & McInerney, D. (2012). Academic motivation, self-concept, engagement, and performance in high school: Key processes from a longitudinal perspective. *Journal of Adolescence, 35*, 1111-1122. doi:10.1016/j.adolescence.2012.02.016

Guthrie, R., & Carlin, A. (2004). Waking the dead: Using interactive technology to engage passive listeners in the classroom. In *Proceedings of the Tenth Americas*

Conference on Information Systems, New York, New York, August 2004 (pp. 2952-2959). Retrieved from https://aisel.aisnet.org/amcis2004/index.2.html

Haystead, M. W., & Marzano, R. J. (2009). *Meta-analytic synthesis of studies conducted at Marzano Research Laboratory on instructional strategies.* Englewood, CO: Marzano Research Laboratory.

Heaslip, G., Donovan, P., & Cullen, J. (2014). Student response systems and learner engagement in large classes. *Active Learning in Higher Education, 15*(1), 11-24. doi:10.1177/1469787413514648

Hedgcock, W., & Rouwenhorst, R. (2014). Clicking their way to success: Using student response systems as a tool for feedback. *Journal for Advancement of Marketing Education, 22*(2), 16-25.

Herreid, C. (2006). “Clicker” cases: Introducing case study teaching into large classrooms. *Journal of College Science Teaching, 36*(2), 43-47. Retrieved from http://www.physics.emory.edu/faculty/weeks//journal/Herreid_JCST1006.pdf

Hoffman, C., & Goodwin, S. (2006). A clicker for your thoughts: Technology for active learning. *New Library World, 107*, 422-433. doi:10.1108/03074800610702606

Horn, I. (2006). Lessons learned from detracked mathematics departments. *Theory Into Practice, 45*, 72-81. doi:10.1207/s15430421tip4501_10

Huebner, T. (2010). Differentiated instruction. *Educational Leadership, 67*(5), 79-81.

Ireh, M., & Ibeneme, O. (2010). Differentiating instruction to meet the needs of diverse technical/technology education students at the secondary school level. *African Journal of Teacher Education, 1*(1), 106-114.

Johnson, D., & McLeod, S. (2004). Get answers: Using student response systems to see students' thinking. *Learning & Leading With Technology, 32*(4), 18-23.

Johnson, K., & Lillis, C. (2010). Clickers in the laboratory: Student thoughts and views. *Interdisciplinary Journal of Information, Knowledge and Management, 5*, 139-151. Retrieved from http://ijikm.org/Volume5/IJIKMv5p139-151Johnson445.pdf

Joseph, S., Thomas, M., Simonette, G., & Ramsook, L. (2013). The impact of differentiated instruction in a teacher education setting: Successes and challenges. *International Journal of Higher Education, 2*(3), 28-40. doi:10.5430/ijhe.v2n3p28

Kaleta, R., & Joosten, T. (2007). Student response systems: A University of Wisconsin System study of clickers. *EDUCAUSE Research Bulletin, 2007*(10), 1-12. Retrieved from https://library.educause.edu/~/media/files/library/2007/5/erb0710-pdf.pdf

Kay, R., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education, 53*, 819-827. doi:10.1016/j.compedu.2009.05.001

Keough, S. (2012). Clickers in the classroom: A review and a replication. *Journal of Management Education, 36*, 822-847. doi:10.1177/1052562912454808

Lein, A. E., Jitendra, A. K., Starosta, K. M., Dupuis, D. N., Hughes-Reid, C., & Star, J. R. (2016). Assessing the relation between seventh-grade students' engagement and mathematical problem solving performance. *Preventing School Failure, 60*(2), 117-123. doi:10.1080/1045988X.2015.1036392

Levy, H. M. (2008). Meeting the needs of all students through differentiated instruction: Helping every child reach and exceed standards. *The Clearing House, 81*, 161-164. Retrieved from https://www.jstor.org/stable/30189983

Li, Q., & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review, 22*, 215-243. doi:10.1007/s10648-010-9125-8

Lincoln, D. J. (2008). Teaching with clickers in the large-size Principles of Marketing class. *Marketing Education Review, 18*(1), 39-45. doi:10.1080/10528008.2008 .11489023

MacGeorge, E., Homan, S., Dunning, J., Elmore, D., Bodie, G., Evans, E., . . . Geddes, B. (2008). Student evaluation of audience response technology in large lecture classes. *Educational Technology, Research and Development, 56*, 125-145. doi:10 .1007/s11423-007-9053-6

Martin, A., Anderson, J., Bobis, J., Way, J., & Vellar, R. (2012). Switching on and switching off in mathematics: An ecological study of future intent and disengagement among middle school students. *Journal of Educational Psychology, 104*, 1-18. doi:10.1037/a0025988

Marzano, R. J. (2010a). Representing knowledge nonlinguistically. *Educational Leadership, 67*(3), 10-17.

Marzano, R. J. (2010b). Using games to enhance student achievement. *Educational Leadership, 67*(5), 71-72.

Marzano, R. J., & Heflebower, T. (2011). Grades that show what students know. *Educational Leadership, 69*(3), 34-39.

McTighe, J., & O'Connor, K. (2005). Seven practices for effective learning. *Educational Leadership, 63*(3), 10-17.

Morales, L. (2011). Can the use of clickers or continuous assessment motivate critical thinking? A case study based on corporate finance students. *Higher Learning Research Communications*, *1*(1), 33-42. Retrieved from ERIC database. (EJ1134341)

No Child Left Behind Act of 2001, Pub. L. No. 107-110, § 115, Stat. 1425 (2002).

Parsons, J., & Taylor, L. (2011). Improving student engagement. *Current Issues in Education*, *14*(1), 1-32. Retrieved from https://cie.asu.edu/ojs/index.php/cieatasu/article/view/745

Pellegrino, W., & Quellmalz, E. (2010). Perspectives on the integration of technology and assessment. *Journal of Research on Technology in Education, 43*, 119-134. doi:10.1080/15391523.2010.10782565

Penuel, W. R., Boscardin, C. K., Masyn, K., & Crawford, V. M. (2007). Teaching with student response systems in elementary and secondary education settings: A survey study. *Educational Technology, Research and Development*, *55*, 315-346. doi:10.1007/s11423-006-9023-4

Prensky, M. (2008). Turning on the lights. *Educational Leadership, 65*(6), 40-45.

Preszler, R., Dawe, A., Shuster, C., & Shuster, M. (2007). Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *Life Sciences Education*, *6*(1), 29-41. doi:10.1187/cbe.06-09-0190

Rothstein, R., & Jacobsen, R. (2006). The goals of education. *Phi Delta Kappan, 88*, 264-272. doi:10.1177/003172170608800405

Santangelo, T., & Tomlinson, C. A. (2009). The application of differentiated instruction in postsecondary environments: Benefits, challenges, and future directions.

International Journal of Teaching and Learning in Higher Education, 20, 307-323. Retrieved from http://www.isetl.org/ijtlhe/pdf/IJTLHE366.pdf

Santangelo, T., & Tomlinson, C. A. (2012). Teacher educators' perceptions and use of differentiated instruction practices: An exploratory investigation. *Action in Teacher Education, 34*, 309-327. doi:10.1080/01626620.2012.717032

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *Journal of Educational Research, 95*, 323-332. doi:10.1080/00220670209596607

Small Enterprises Research and Development Foundation. (2012). *SERDEF study seeks to build enterprising K to 6 pupils*. Retrieved from http://serdef.org/2012/10/serdef-study-seeks-to-build-enterprising-k-1-pupils/

Snyder, J., & Metz, M. (2012). *Carnegie Learning coordinate algebra*. Pittsburgh, PA: Carnegie Learning.

Stagg, A., & Lane, M. (2010). Using clickers to support information literacy skills development and instruction in first-year business students. *Journal of Information Technology Education, 9*, 197-215. Retrieved from http://www.jite.org/documents/Vol9/JITEv9p197-215Stagg800.pdf

Stiggins, R. (2005). From formative assessment to assessment FOR learning: A path to success in standards-based schools. *Phi Delta Kappan, 87*, 324-328. doi:10.1177/003172170508700414

Stiggins, R. J., & Chappuis, J. (2012). *An introduction to student-involved assessment FOR learning* (6th ed.). Upper Saddle River, NJ: Pearson.

Sun, J., Martinez, B., & Seli, H. (2014). Just-in-time or plenty-of-time teaching?

Different electronic feedback devices and their effect on student engagement. *Journal of Educational Technology & Society*, *17*, 234-244.

Terrion, J., & Aceti, V. (2012). Perceptions of the effects of clicker technology on student learning and engagement: A study of freshmen chemistry students. *Research in Learning Technology*, *20*(2), 1-11. doi:10.3402/rlt.v20i0.16150

Tomlinson, C. A. (2004). Point/counterpoint: Sharing responsibility for differentiating instruction. *Roeper Review, 26*, 188-189. doi:10.1080/02783190409554268

Tomlinson, C. A., & Imbeau M. (2010). *Leading and managing a differentiated classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.

Toshalis, E., & Nakkula, M. J. (2012). Motivation, engagement, and student voice. *The Education Digest*, *78*(1), 29-35. Retrieved from ERIC database. (EJ999430)

Trees, A., & Jackson, M. (2007). The learning environment in clicker classrooms: Student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media, and Technology, 32*, 21-40. doi:10.1080/17439880601141179

Wang, Y., Chung, C., & Yang, L. (2014). Using clickers to enhance student learning in mathematics. *International Education Studies, 7*(10), 1-13. doi:10.5539/ies .v7n10p1

Wenglinsky, H. (2005). Technology and achievement: The bottom line. *Educational Leadership, 63*(4), 29-32.

White-Clark, R., DiCarlo, M., & Gilchriest, N. (2008). “Guide on the side”: An instructional approach to meet mathematics standards. *The High School Journal,* *91*(4), 40-44.

Wolter, B., Lundeberg, M., Kang, H., & Herreid, C. (2011). Students' perceptions of using personal response systems ("clickers") with cases in science. *Journal of College Science Teaching*, *40*(4), 14-19.

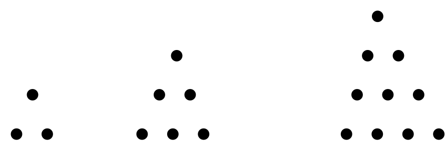
Appendix A

Pretest Benchmark Assessment

Pretest Benchmark Assessment: Week 1

Coordinate Algebra Sequences Pretest Name___________________________

1. Consider the sequence shown.



   a. Describe the pattern.

   b. Draw the next two figures of the pattern.

   c. Write a numeric sequence to represent the first 5 sequences.

2. Identify each sequence as arithmetic or geometric. Then determine the common difference or common ratio for each sequence.

   a. 2, 5, 8, 11, 14, 17

   b. -6, 12, -24, 48, -96

3. For each sequence, write an explicit formula. Then determine the 15^{th} term in the sequence.

   a. 5, 10, 20, 40, 80, 160

   b. $\frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, \frac{7}{2}$

4. For each sequence, write a recursive formula. Then determine the unknown term in the sequence.

   a. 0.15, 0.17, 0.19, 0.21, _____

   b. $\frac{1}{6}, \frac{1}{12}, \frac{1}{24}$, _______, $\frac{1}{96}$

5. Rewrite each explicit formula in function form.

   a. $a_n = 5 + 0.2(n - 1)$

   b. $g_n = 3 \cdot (-2)^{n-1}$

Appendix B

Posttest Benchmark Assessment

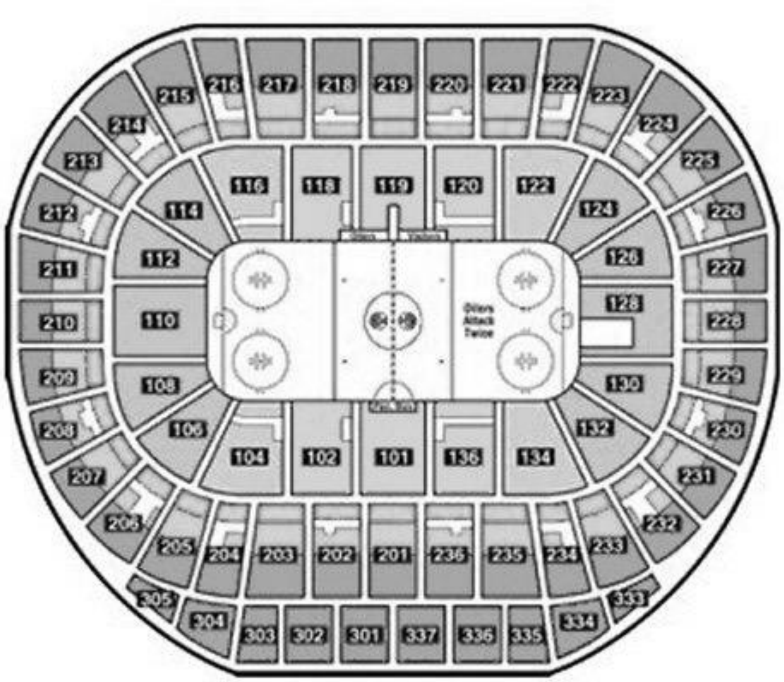
Posttest Benchmark Assessment: Week 9

Student Performance Task #1: Arena Plan **Name_________________________**

Scenario

Mr. Doolittle has asked you to design a seating plan for a new NHL arena. Currently his team plays in a rink like the one below.

Sample Arena



You must submit a proposal to Mr. Doolittle that outlines the following information. Support your proposal with appropriate mathematics.

Student Performance Task #1: **Arena Plan** **Name________________________**

1. Mr. Doolittle wants the number of seats in the arena to be between 18,000 and 22,500. One ring of seats all the way around the rink is considered a row, and row 1 is considered to be the row closest to the ice. He wants the number of seats in each row to form an arithmetic sequence, increasing by the same number in each subsequent row. Your task is to decide on the total number of seats in the arena by designing a seating arrangement that has a reasonable number of rows by determining:

    a. The number of seats in the first row.
    b. The number of rows required.
    c. The number of seats by which each row increases.
    d. The number of seats in the last row.
    e. The total number of seats in the arena.

2. In his current arena, Mr. Doolittle charges $6000 per season for seats in rows 1-10, $4000 for season seats in rows 11-20, $3000 for season seats in rows 21-30, and $2000 for season seats in rows 31-40. He thinks that a more fair way to decide on season ticket prices is to use a geometric sequence, and decrease the price in each subsequent row by the same factor based on the price of the row in front of it. For your proposal:

    a. Determine a reasonable price per game for each seat in the first row.
    b. Determine the factor by which the cost of each seat per game will decrease in each subsequent row from row 1.
    c. Determine the price per game of each seat in the last row.

3. There are 41 home games in the regular season. Given that he needs to sell every seat in the arena and generate at least $50,000,000 in revenue, determine the following:

    a. The total revenue he will generate by selling all the seats in his rink at the prices you set above. You may have to adjust the prices you set above in order to generate at least $50,000,000 in revenue.

Your proposal can take any form but must be supported by mathematics.

Student Performance Task #1: **Arena Plan Rubric** **Name________________________**

Criteria	**Meets expectations at high level. (8-10)**	**Meets expectations. (6-7)**	**Does not meet expectations. (1-5)**
All required elements are present and correct. (10 points)	Included a seating arrangement that tells the number of seats in the first row, the number of required rows, the number of seats by which each row increases, the number of seats in the last row, and the total number of seats in the arena.	Included some but not all of the following: a seating arrangement that tells the number of seats in the first row, the number of required rows, the number of seats by which each row increases, the number of seats in the last row, and the total number of seats in the arena.	Included a seating arrangement but did not tell the number of seats in the first row, the number of required rows, the number of seats by which each row increases, the number of seats in the last row, or the total number of seats in the arena.
Presentation of data is clear, precise and accurate. (10 points)	Determined a reasonable price per game for each seat in the first row; the factor by which the cost of each seat per game will decrease; and the price per game of each seat in the last row.	Determined a price per game for each seat in the first row; the factor by which the cost of each seat will decrease for some games but not per game; and the price per game of each seat in the last row.	Determined a price per game for each seat in the first row but did not determine the factor by which the cost of each seat per game will decrease nor the price per game of each seat in the last row.
Provides insightful explanations. (10 points)	Determined the total revenue to be generated by selling all seats.	Determined the total revenue to be generated by selling all seats but the amount was off by a dollar.	Did not determine the correct total revenue to be generated by selling all seats.

When work is judged to be limited or insufficient, the teacher makes decisions.

Student Performance Task #2: Community Service, Sequences, and Functions
(Based on Common Core Georgia Performance Standards, 2014)

Name_________________________

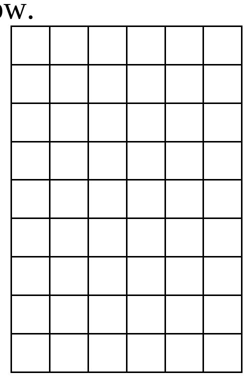
Scenario

Larry, Moe, and Curly spend their free time doing community service projects. They would like to get more people involved. They began by observing the number of people who show up to the town cleanup activities each day. The data from their observations is recorded in the given table for the Great Four Day Cleanup.

x	*y*
1	5
2	27
3	49
4	71

1. Give a verbal description of what the domain and range presented in the table represents.

2. Sketch the data on the grid below.



3. Determine the type of function modeled in the graph above and describe key features of the graph.

4. Based on the pattern in the data collected, what recursive process could Larry, Curly, and Moe write?

5. Write a linear equation to model the function.

6. How would Larry, Curly, and Moe use the explicit formula to predict the number of people who would help if the cleanup campaign went on for 7 days?

Excited about the growing number of people participating in community service, Larry, Curly, and Moe decide to have a fundraiser to plant flowers and trees in the parks that were cleaned during the Great Four Day cleanup. It will cost them $5,000 to plant the trees and flowers. They decide to sell some of the delicious pies that Moe bakes with his sisters. For every 100 pies sold, it costs Moe and his sisters $20.00 for supplies and ingredients to bake the pies. Larry, Curly, and Moe decide to sell the pies for $5.00 each.

7. Complete the following table to find the total number of pies sold and the amount of money the trio collects.

   a. On Day 1, each customer buys the same number of pies as his customer number. In other words the first customer buys 1 pie, the second customer buys 2 pies. Fill in the table showing the number of pies and the amount collected on Day 1. Then calculate the total number of pies sold and dollars collected.

   b. Write a recursive and explicit formula for the pies sold on Day 1. Explain your thinking.

Customer Number	***Number of Pies Sold***	***Amount Collected***
1	***1***	***$5***
2	***2***	***$10***
total		

   c. On Day 2, the first customer buys 1 pie, the second customer buys 2 pies, the third customer buys 4 pies, the fourth customer buys 8 pies, and so on**.** Complete table based on the pattern established. Then calculate the total number of pies sold and dollars collected.

   d. Write a recursive and explicit formula for the pies sold on Day 2. Explain your thinking.

Customer Number	***Number of Pies Sold***	***Amount Collected***
1	***1***	***$5***
2	***2***	***$10***
Total		

8. Compare the rates of change on Day 1 and Day 2 for the number of pies sold.

9. Did Larry, Curly, and Moe earn enough in two days to fund their project? Consider costs incurred to bake the pies. Justify your reasoning.

Student Performance Task #2: **Community Service, Sequences, and Functions Rubric**

Name_________________________

Criteria	**Meets expectations at high level. (8-10)**	**Meets expectations. (6-7)**	**Does not meet expectations. (1-5)**
Explanation (10 points)	A complete response with a detailed explanation.	Good solid response with clear explanation.	Explanation is unclear.
Use of Visuals (5 points)	Tables and graph show the correct number of days and the number of people who showed up each day for the cleanup campaign. Tables and graph show the correct number of pies sold and the amount collected.	Tables but no graph show the correct number of days and the number of people who showed up each day for the cleanup campaign. Tables but no graph show the correct number of pies sold and the amount collected.	Tables and graph show the correct number of days but the incorrect number of people who showed up each day for the cleanup campaign. Tables and graph show the correct number of pies sold but the incorrect amount collected.
Mechanics (10 points)	No math errors.	No major math errors or serious flaws in reasoning.	May be some serious math errors or flaws in reasoning.
Demonstrated Knowledge (10 points)	Shows complete understanding of the questions, mathematical ideas, and processes.	Shows substantial understanding of the problem, ideas, and processes.	Response shows some understanding of the problem.
Requirements (5 points)	Goes beyond the requirements of the problem.	Meets the requirements of the problem.	Hardly meets the requirements of the problem.

Appendix C

Interim Benchmark Assessment

Interim Benchmark Assessment: Week 4 and Week 6

Coordinate Algebra Sequences Mid-Chapter Test   Name___________________________

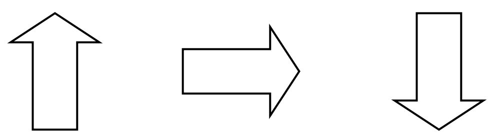
1. Kerryn's Pizza Shop made 16 pizzas on Monday, 22 pizzas on Tuesday, and 28 pizzas on Wednesday. If this pattern continues, how many pizzas will Kerryn's Pizza Shop make on Friday?

2. Consider this sequence: 4, 12, 36, 108, 324, 972.

   a. Describe the pattern.

   b. What is the next number in the pattern?

3. Consider the sequence shown.



   a. Describe the pattern.

   b. Draw the next two figures of the pattern.

4. Write the first 4 terms of each sequence.

   a. an arithmetic sequence with a common difference of 7 and a first term of -12

   b. a geometric sequence with a common ratio of 0.1 and a first term of 100

5. Identify each sequence as arithmetic or geometric. Then determine the common difference or common ratio for each sequence.

   a. 5, 3.5, 2, 0.5, -1

   b. 1, 6, 36, 216, 1296

6. Brad makes two phone calls to his friends to tell them school is cancelled because of snow. Each of those friends makes two calls to tell their friends the same news. Each of those friends makes two calls to tell their friends the same news, and so on.

   a. Write a numeric sequence to represent the number of calls made in each of the first 5 sets of phone calls.

   b. Is this an arithmetic or geometric sequence?