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The Relationship Between I-Ready Intervention and Grade 8 Mathematical Achievement

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THE RELATIONSHIP BETWEEN I-READY INTERVENTION AND GRADE 8 MATHEMATICAL ACHIEVEMENT

by Kenyatta Shanta Aldridge

This dissertation has been read and approved as fulfilling the partial requirement for the Degree of Doctor of Education in Curriculum and Leadership.

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DEDICATION

I would like to dedicate this dissertation to my husband, three children, and my parents. These outstanding people have sacrificed so much as I spent countless hours on the road, in front of a computer completing homework, or working on my dissertation. Thank you, thank you, thank you!

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ABSTRACT

A problem exists in using educational software as an intervention for middle grades mathematics. The rural middle school used an educational program to improve mathematical achievement; however, the effectiveness of this program was not evaluated. The e-learning theory served as the theoretical framework for this study. The purpose of this explanatory, sequential mixed methods design was to examine the relationship between the i-Ready intervention program and students' mathematical achievement and to explore teachers' perceptions of implementing the i-Ready intervention program. The participants included 48 Grade 8 students from one middle school. A series of bivariate correlations was conducted using the diagnostic data from the i-Ready program, number of completed i-Ready lessons, and standardized mathematics assessment scores. An intrinsic case study was conducted using interviews from two teachers. The interviews were coded, and common themes were identified. The teachers perceived that the program could help students learn mathematical content if appropriate training was provided. The implications for the study include the need for professional learning and ongoing support for teachers to implement the program effectively.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background of the Problem

Educational technology was defined by Delgado, Wardlow, McKnight, and O'Malley (2015) as instruction delivered to students via computers using games, software, hardware, or real-world simulations. In educational settings, technological tools are designed to transform traditional methods of teaching to improve student learning (Mahmoudi, Koushafar, Saribagloo, & Pashavi, 2015). Researchers, including Foster, Anthony, Clements, Sarama, and Williams (2016), Kiriakidis and Geer (2014), and Securro, Jones, Cantrell, and Blackwell (2006), suggested that technology-based resources, such as computer software and online instructional programs, are valuable supplemental tools that can support student learning and can influence student achievement in mathematics at all grade levels.

In 2013, the U.S. government spent 0.7% of the $1.5 trillion educational budget on e-Learning (Delgado et al., 2015). Electronic-learning (e-Learning) is identified as learning through electronic forms (Kibuku & Ochieng, 2019), and e-learning systems allow learning to be generated through web-based applications (Freeze, Alshare, Lane, & Wen, 2019). The e-learning theory is used to explain how knowledge is achieved with technology. The theory identifies how people, services, and technologies promote student learning (Apracio et al., 2016). To demonstrate how students learn, Morales (2016) identified how technology aided differentiation in mathematical instruction. Technology was implemented to provide instruction that tailored to the educational needs of all students.

Educational technology is defined as a tool to enhance instruction (Cannon, 2009; Dempsey & Kuhn, 2011), and teachers implement educational technology in classrooms (Biemans, Gulikers, Van der Wel, & Wesselink, 2013). Smith and Thorne (2009) identified different uses of educational technology, which include increased student engagement and differentiated instruction, and identified student readiness and learning styles. Computer technology utilized to enhance instruction include iTechnology (i.e., iPod and iPad), educational applications, and mobile games (Banister, 2010).

In the 21st century, students are referred to as “digital natives” (Prenksy, 2001), “next generation” (Tapscott, 1998), and “millennials” (Howe & Strauss, 2000, 2003). Howe and Strauss (2000) described students as being immersed in technology and reliant on communicational technology to learn. In 2000, the National Council of Teachers of Mathematics reported that technology was crucial to teach and motivate students to learn mathematics (Zhang, Trussell, Gallegos, & Asam, 2015). Akcaoglu, Gutierrez, Hodges, and Sonnleitner (2017) indicated that game-based learning was an effective method to improve problem-solving skills in mathematics. Results from the Akcaoglu et al.’s (2017) quantitative study displayed how game design and learning programs significantly improved students’ complex-problem solving skills. Mahmoudi et al. (2015) conducted a study to determine if computer games impacted different elements of students’ mathematical ability. Results from the statistical data indicated that students’ attention and mathematical calculation skills increased. The results from the study also identified improved attitudes towards learning for struggling females who used the traditional method of learning mathematics. For males, no effect was identified on academic achievement or attitudes. To determine a relationship between technology usage and student achievement, Carr (2012), Cheung and Slavin (2013), and Chu (2014) conducted correlational studies. Chu (2014) investigated reasons why student achievement did not improve when technology was implemented. Carr (2012) conducted a study where participants utilized educational technology to learn mathematics, but student achievement was not affected. Although the studies by Carr (2012), Cheung and Slavin (2013), and Chu (2014) did not yield increased student achievement, Cheung and Slavin's (2013) study indicated that educational technology produced a small effect on mathematical achievement.

Studies were conducted in all content areas, and the most difficult area to determine significant results was in the field of mathematics. Lowrie and Jorgensen (2011) stated that integrating educational technology was challenging due to the difficulty of thinking and learning in the subject. Çelik, Erduran, and Eryiğit (2017) stated that mathematical achievement could increase by learning the content with educational software. As reported by Banister (2010), educational software allows students the opportunity to practice computation and basic mathematical problems. Different educational software was created to increase mathematical achievement. Kiili, Devlin, Perttula, Tuomi, and Lindstedt (2015) conducted a study to determine if computer games, combined with learning and assessment, impacted mathematical achievement. The results from the study indicated that a computer game could impact and assess student learning.

In a study conducted by Kiger, Herro, and Prunty (2012), educational software was used as an intervention to improve mathematical skills. Intervention was defined as instruction during a certain period to teach a specific curriculum (Jansen, 2005).

Curriculum Associates (2015b) identified i-Ready was a software that uses diagnostics, differentiated K–8 online instruction, and teacher-led instruction. According to i-Ready's Administrators' Guide, the program provides diagnostic data on students' mathematical strengths and weaknesses (Curriculum Associates, 2016). The i-Ready diagnostic provides teachers with individual student's needs in different domains of mathematics. From the diagnostic data, the program also develops a personalized learning path for each student, ensuring the intervention matches the learning needs (Curriculum Associates, 2016). Bouck and Cosby (2017) identified this intervention, response to intervention, as providing early assistance to students who struggle with mathematics. Morales (2016) conducted a study to determine if educational software could be used as an intervention to differentiate instruction. The results from the study indicated that educational software was effective in decreasing learning gaps and increasing students' motivation to learn.

Statement of the Problem

Educational technology has enriched the learning process to improve students' academic performance (Garneli, Giannakos, & Chorianopoulous, 2017). A problem exists in using educational software as an intervention for middle grades mathematics. Given the lack of empirical evidence, one problem is identifying the relationship between a computer-managed instruction (i.e., i-Ready) and middle grades mathematical achievement. Studies with other educational software by Mulqueeny, Kostyuk, Baker, and Ocumpaugh (2015), Sharp and Hamil (2017), and Yilmaz (2017) identified how programs impacted student achievement; however, limited research was available on how the use of i-Ready impacted middle grades mathematical achievement. The limited research conducted on Grade 8 students highlighted negative effects of using educational software to learn mathematical content and did not yield positive gains on student achievement when an educational software was used to learn mathematical skills. This study examined mathematical achievement using educational software with the e-learning theory. The study contributed to the body of knowledge needed to address this problem by examining the relationship between i-Ready intervention and mathematical achievement. The present study targeted a public school in Southwest Georgia, focusing on eighth-grade middle school students and teachers.

Purpose of the Study

This mixed methods research study addressed the relationship between the computer-managed instruction, i-Ready, and mathematical achievement as measured by i-Ready diagnostic data and Georgia Milestones Assessment System (GMAS) data. An explanatory sequential research design was used to examine the quantitative data and explore the qualitative interview data. In this study, continuous data were used to examine the relationship between the number of completed i-Ready lessons, i-Ready gain scores (i.e., the posttest subtract the pretest), GMAS Mathematics scale scores, and GMAS Mathematics achievement levels for Grade 8 students at a rural middle school in Georgia. The intrinsic case study explored teachers' perceptions of implementing the i-Ready intervention program at a rural middle school in Georgia. The reason for collecting both quantitative and qualitative data was to understand the relationship between the i-Ready intervention program and mathematical achievement.

Research Questions and Hypotheses

The purpose of the study was to examine the relationship between the i-Ready intervention program and students' mathematical achievement and to explore teachers' perceptions of implementing the i-Ready intervention program. The explanatory sequential mixed methods research study aimed to answer the following research questions:

1. What is the relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students?

   H_{o1} There is not a relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students.

   H_{a1}: There is a relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students.

2. What is the relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students?

   H_{o2}: There is not a relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

   H_{a2}: There is a relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

3. What is the relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students?

   H_{o3}: There is not a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

$H_{a}3$: There is a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

4. What is the relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students?

   $H_{o}4$: There is not a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

   $H_{a}4$: There is a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

5. What are the average i-Ready gain scores for each GMAS Mathematics achievement level for eighth-grade students?

6. What are middle school mathematics teacher perceptions of implementing the i-Ready intervention program?

Theoretical Framework

Kiili et al. (2015) stated societal development is impacted by students' mathematical knowledge. To assist in students with learning mathematics, Kiili et al. recognized the need for differentiation to increase student engagement in classrooms. Kiili et al. conducted a study that focused on school districts using computer games to increase student engagement and achievement in mathematics classrooms. In the study, the e-learning theory was used to identify the need for computer games to aid in teaching mathematical content. Aparicio, Bacao, and Oliveira (2016) stated that the e-learning theory consists of learning with technology. Students use technology to interact and work with others to complete assignments (Aparicio et al., 2016). Dabbagh (2005) also acknowledged that the e-learning theory is composed of how people learn and the pedagogical ways to learn. Zinn (2000) stated the e-learning theory derived from the views of computer-assisted instruction. The e-learning theory consists of three components, which include people, technology, and services (Aparicio et al., 2016). The people involved in the e-learning theory are stakeholders, such as customers, suppliers, professional associations, special interest groups, and school board members. The technology component of the theory contains different types of content, communication, and collaboration resources to assist in learning. The services are activities, such as pedagogical models and instructional strategies, to provide differentiated resources to assist in student learning.

Methodology Overview

An explanatory sequential mixed methods design (QUAN → qual) was used in the quantitative driven study. In the study, the quantitative phase was highlighted, and qualitative data were added to the study (Johnson & Christensen, 2019). In Phase 1, quantitative data were collected from i-Ready diagnostic data and GMAS Mathematics scale scores. Statistical software (SPSS) was used to examine the relationship between the quantitative data. In Phase 2, qualitative interviews were used to explore teachers' perceptions regarding the i-Ready intervention program. Throughout the interview, the researcher used open-ended questions, with words or phrases, to gather the participants' responses (Colorado State University, 2011). The use of open-ended questions allowed the interviewee to communicate an opinion without the influence of the researcher (Froddy, 1993). From the interviews, the researcher coded the interview data and categorized the transcribed data to display the findings (Johnson & Christensen, 2019).

After this procedure, the researcher identified themes within the codes, counted the outcomes, and identified relationships within the data (Johnson & Christensen, 2019).

Quantitative Phase

A correlational research design was used to analyze data from the i-Ready software program and GMAS Mathematics scale scores to determine if a relationship existed. Johnson and Christensen (2019) classified correlational research as identifying the relationship between one or more autonomous or dependent variables. The researcher conducted a correlational study to analyze gain scores from the pretest and posttest results. The researcher calculated each student's gain score by subtracting the posttest score and the pretest score (Knapp & Schafer, 2009). Next, a series of bivariate correlation analyses and descriptive statistics analyses was conducted to examine the relationship between the number of completed i-Ready lessons, the i-Ready gain scores (i.e., geometry, number sense, and algebra), the GMAS Mathematics scale scores, and the GMAS Mathematics achievement levels (i.e., beginning, developing and proficient).

The participants in the quantitative phase were Grade 8 students from the 2018 – 2019 school year. Participants were selected for the study based on STAR Math scale scores and response to intervention tier (i.e., II or III). During the school year, participants used an educational software for 18 weeks to learn mathematical concepts, and diagnostic data were collected by the program. Participants in the study completed the i-Ready intervention lessons in the mathematics lab twice a week for 60 minutes each session and in the general mathematics classroom two or three times a week for 30 minutes each session.

The computer-managed instruction was i-Ready, which administered progress monitoring and diagnostic assessments to students three times a year. The diagnostic instrument measured student knowledge in four areas, which included number sense, algebra and algebraic thinking, measurement and data, and geometry. Results from the diagnostic assessments were used to develop individualized learning paths. The i-Ready Diagnostic was designed to align with college and career readiness standards, including the Georgia Standards of Excellence, and measured students' progress toward meeting those standards (Curriculum Associates, 2016). The i-Ready program served as an intervention for low-performing Grade 8 students. Teachers used the data from the diagnostic reports to provide supplemental support and individualized instruction to students.

Qualitative Phase

An intrinsic case study research design was used to explore teachers' perceptions when using the i-Ready software to provide mathematics intervention. Baxter and Jack (2010) stated a case study is used to explore an experience by analyzing variations of resources. With a variety of resources, the issue was explored from more than one perspective to understand and reveal various components of the phenomenon (Baxter & Jack, 2010). Johnson and Christensen (2019) stated that case study research provides a detailed explanation and examination of the characteristics and changes in one or more situations. Yin (2003) stated that a case study should be used if the focus of the study is to answer "how and "why" questions. With a case study, the researcher wanted to explore background perceptions related to the study (Yin, 2003). Luck, Jackson, and Usher (2006) considered a case study to involve intensive and detailed qualitative and quantitative data collection about the study. The case study framework is used to build a comprehensive understanding of the study (Creswell, 2009).

The researcher conducted an intrinsic case study with two Grade 8 certified mathematics teachers. Purposive sampling was used to identify two participants for the case study. The researcher interviewed two Grade 8 mathematics teachers (i.e., Teacher A and Teacher B) who used the software program to provide intervention services. The results from the interviews identified teachers' perceptions regarding implementing the i-Ready intervention program.

Integration Phase

The integration of quantitative and qualitative data was used to examine different groups to understand relationships and explain or develop the results by mixing data (Plano Clark et al., 2013). Qualitative data were used to measure the effectiveness of the quantitative results, and the quantitative data were used to create the qualitative sample or justify findings from the qualitative information (Fetters et al., 2013). When the researcher collects quantitative data with an instrument with scales, comparable or corresponding questions were used to collect the qualitative data (Castro, Kellison, Boyd, & Kopak, 2010). The data sets were individually analyzed to answer the qualitative and quantitative research questions, as well as to test the hypothesis (Terrell, 2015).

After both sets of data were analyzed, the researcher integrated the results by merging the quantitative and qualitative data. Merging the data combined the qualitative data in the form of texts or images with the quantitative data in the form of numeric information (Creswell et al., 2011). The data were merged and synthesized to identify themes or patterns that indicated a relationship between eighth grade mathematical achievement and i-Ready. During the merging process, the researcher combined the quantitative and qualitative data to compare the results with joint displays to provide visual presentations of the data using a matrix (Fetters et al., 2013; Miles & Huberman, 1994). Fetters et al. (2013) stated that joint displays organize data in a diagram, chart, model, or display. Joint displays enhanced the results from merging the quantitative and qualitative data (Bazeley, 2009, 2012; Fetters & Freshwater, 2015; Guetterman et al., 2015; O'Cathain et al., 2007; Yin, 2006).

Delimitations and Limitations

Delimitations to this research were time spent on the program and the number of weeks for the study. Limitations of the study were conducting the research using one school district and the use of purposive and convenience sampling to select the sample population. This study took place in a middle school in rural Georgia. When this type of sample selection is used, external validity could be affected, and the ability to generalize from a sample to a population is limited (Johnson & Christensen, 2019). Another limitation was the time between analyzing the quantitative data (2018 – 2019) and interviewing teachers in 2020. The type of quantitative data used in the study could provide another limitation. The researcher used Georgia Milestones data (procedural) and i-Ready data (not procedural) to determine if student achievement improved. An additional limitation was the number of teachers selected for the study; only two teachers were used for the study. Johnson and Christensen (2019) stated a random sample should be selected that is large enough to represent the population and able to discover group differences or relationships.

Two assumptions were made in this study. First, students who were in Tier II and III interventions would show improvement in mathematics scores. Kane (2018) identified response to intervention was composed of three tiers to provide quality instruction to students. In Tier I instruction, teachers provide routine classroom instruction to all students (Mellard et al., 2010), which utilize whole-group strategies with differentiated activities (Jones, Yssel, & Grant, 2012). Students completed the classroom assignments independently, in small groups, or in pairs (Jones et al., 2012). Students in Tier II and III received comprehensive assessments, growth checkpoints, evidence-based interventions, and conformity measures (Bradley, Danielson, & Doolittle, 2005). The second assumption was that i-Ready, which was the computer-managed instruction administered during the research period, could impact GMAS Mathematics scale scores.

Definition of Terms

The following definitions were used in this study:

- *Computer-Based Instruction (CBI*) – "an umbrella term for use of computers in both instruction and management of teaching and learning process" (Bhalla, 2013, p. 177).
- *Educational technology* – "used to reference computer-assisted instruction, simulations, games, or laboratory instruments, or technology software/hardware" (Delgado, Wardlow, McKnight, & O'Malley, 2015, p. 400).
- *Educational Software* – "evaluated by the way of the user experience, ease of use and perceived usefulness" (Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2016, p. 525).

- *Electronic learning (e-Learning)* - learning via electronic sources, such as television, computer, videodisk, teletext, or videotext (White, 1983, p. 13).
- *Georgia Milestones End of Grade Assessment (Georgia Milestones)* – "The Georgia Milestones Assessment System (Georgia Milestones) is a comprehensive summative assessment program that spans grades three through high school. Georgia Milestones measures how well students have learned the knowledge and skills outlined in the state-adopted content standards in English language arts (ELA), mathematics, science, and social studies. Georgia Milestones is designed to provide students with critical information about their own achievement and readiness for their next level of learning—be it the next grade, the next course, or endeavor (college or career)" (Georgia Department of Education, 2019a, p. 1).
- *i-Ready* - "a robust online platform offering computer-adaptive diagnostic, personalized data-driven instruction on foundation skills, standards-based practice, and a Common Core readiness screener" (Curriculum Associates, 2016, p. 3).
- *Technology* – "used to represent any digital device, operating system, or technological software/hardware that can be used to perform or facilitate an objective" (Delgado et al., 2015, p. 400).

Significance of the Study

Implementing educational technology in classrooms can be traced back to the 1920s with radios and films (Cuban, 2001). Educational technology, as defined by Delgado et al. (2015), was instruction that was delivered to students via a computer, software, hardware, or using real-world simulations to play games. During the 1960s, policymakers began an initiation to input computer technology in schools (Reimann & Aditomo, 2013). After the installment of computer technology in schools, equipment became more affordable and was implemented in all schools (Sheskey, 2010). Schools used computer labs, but teachers had to schedule a time and day to use the computers (Ozel, Yetkiner, & Capraro, 2008). After the 1990s, schools began using computers to assist in delivering content to students, and school districts pushed for classrooms to have educational technology for each student instead of just offering computer labs (Foroughi, 2015).

Researchers, Cabus (2015), Altun and Bektaş (2010), Lewin and McNicol (2015), and Mahomoudi et al. (2016), explained why educational software was significant to student achievement. Cabus (2015) stated schools considered the need to include more digital resources in curriculums to increase student motivation and achievement and to decrease dropout rates. Altun and Bektaş (2010) stated that educational technology was implemented in content-area classrooms to increase student achievement.

Lewin and McNicol (2015) stated that educational technology was needed to develop 21st century skills so students were successful in the workplace. Mahmoudi et al. (2016) stated that technological tools were created to transform classrooms to improve student learning. Technology resources were purchased by school systems, and teachers were given the task to use the computer-managed instruction successfully to improve student scores. A gap in knowledge exists regarding the relationship between computer-managed instruction, i-Ready intervention program, and Grade 8 mathematical achievement.

The results of this study examined the relationship between i-Ready and student mathematical achievement for Grade 8 students along with teachers' perceptions for implementing the i-Ready intervention program. The district did not evaluate the significance of the program before purchasing and implementing the program as a method to provide mathematical intervention to Tier II and III students. One implication of the study could be the school district determining if the program impacted student mathematical achievement. With these findings, the district could identify if continuous funding of the program is necessary to improve student achievement. Finally, the study will provide district leaders with information regarding the type of professional development that teachers need to provide interventions to students effectively.

Summary

A problem exists in identifying the relationship between using computer-managed instruction as an intervention to impact middle grades mathematical achievement. Policymakers in Georgia implemented initiatives across the state to address the record low numbers in mathematical achievement. Technological tools were purchased to increase student achievement by providing teachers with differentiated resources to teach all students. This study was designed to examine the relationship between a computer-managed instructional program and student achievement in mathematics. An explanatory sequential mixed methods design was used to collect and analyze i-Ready pretest and posttest scores, GMAS Mathematics scale scores, and interview data from teachers. The research was conducted using Grade 8 students and teachers in a rural school in southwest Georgia. Chapter II will review the literature of the history of Georgia's mathematical standards, reforms that caused changes to the standards, the e-learning theory, and types of computer-based instruction.

CHAPTER II

REVIEW OF LITERATURE

A problem exists in identifying the relationship between using computer-managed instruction as an intervention to improve mathematical achievement. That problem, specifically, was determining if i-Ready impacts middle grades mathematical achievement. Studies by Mulqueeny et al. (2015), Sharp and Hamil (2017), and Yilmaz (2017) provided evidence on how educational programs affected mathematical achievement in the middle grades. However, limited research was conducted on the use of i-Ready as an intervention to impact mathematical achievement for Grade 8 students. Because of the limited research involving i-Ready, a gap in knowledge exists regarding if the computer-managed instructional program improves mathematical achievement. This problem impacts all grade levels, but this study focused on Grade 8. Many possible factors could contribute to this problem, such as students' prior knowledge, lack of student knowledge with computer games, and participants' age (Kiili et al., 2015). The study contributed to the existing knowledge regarding the relationship between a computer-managed instructional program, i-Ready, and Grade 8 student's mathematical achievement.

Mathematics Throughout the Years

In 1920, the National Council of Teachers of Mathematics was created to provide a platform to dispute ongoing mathematical issues (Klein, 2003). The National Committee on Mathematical Requirements (1923) recommended a mathematics curriculum, emphasized the importance of providing professional development for mathematics teachers, and highlighted the importance of algebra. In the 1940s and 1950s, critics of public education claimed the U.S. public education system "had grown soft, had no interest in quality of intellectual rigor, had abandoned the traditional academic disciplines, were no longer promoting excellence, and were often failing to promote traditional American values" (Johanningmeier, 2010, pp. 351 – 352). The beginning efforts to reform mathematics occurred during the 1954 case of *Brown v Board of Education* of Topeka, Kansas. The U.S. Supreme Court decision from *Brown v. Board of Education* changed the appearance of education in the United States (Chinn, 2004). During the court case, John Davis, an attorney from South Carolina, argued that the result of integrated schools would lead to the mixing of women and children with disabilities. As stated by Chinn (2004), this argument was the leading cause of educational rights for women and children. The decision from *Brown v. Board* determined if a state would offer public education and all citizens could receive the same education. This court case also determined that 'separate but equal' (*Plessy v. Ferguson*) did not apply to public education (Chinn, 2004). The ruling from this case sparked the movement for legislation to create the Elementary and Secondary Education Act of 1965. The act was signed by Lyndon B. Johnson to fight the "War on Poverty" (McLaughlin, 1975). The law represented a commitment by the government to provide all citizens equal access to a quality education (Jeffrey, 1978) by funding professional development, instructional resources, educational programs, and increasing parent involvement (Paul, 2016).

New Math Reform

Kilpatrick (1992) identified New Math as the golden era of mathematics that occurred between the 1950s and 1960s. During this time, the field of mathematics received extensive federal funding to improve the society and economy of the United States (Kilpatrick, 1992). The educational funding was used to increase the number of scholars, academic researchers, and prestigious mathematics teachers to help the United States compete against other countries. To compete internationally, colleges and university professors in the United States identified the problem was caused by an outdated K-12 mathematics curriculum (Jones & Coxford, 1970; Kilpatrick, 1992). With the use of an outdated curriculum, students lacked the ability to calculate, use abstract reasoning, and apply mathematical concepts to other content areas (Woodward, 2004). When this area of need was recognized by universities, Lagemann (2000) identified that there was a shift for excellence in education. The change in education was called the "New Math" reform (Walmsley, 2003). The reform generated the dispute between learning abilities and conceptual understanding (Asempapa, 2017). The new curriculum focused on elementary grades, offering new teaching styles and new mathematical content (Bartell, Bieda, Putnam, Bradfield, & Dominguez, 2015; Walmsley, 2003). Researchers, Jones and Coxford (1970), identified the core of the new mathematics curriculum consisted of structured proof, generalization, and abstract learning. Another researcher, Woodward (2004), stated that the reform focused on customary systems, place value, and different algorithms for dividing, adding, and subtracting fractions. In addition, Asempapa (2017) stated that the reform introduced calculus courses in high school. Bartell et al. (2015) described the focus of the new reform was to reduce drills to teach mathematics and use pedagogical styles to support student development of conceptual understanding. Mathematician, Max Beberman, and researchers, Bartell et al. (2015), identified that the goal of the New Math reform was to improve student understanding of concepts by discovery learning. Langemann (2000) linked discovery learning with creating observations and determining patterns, which could enhance the transfer of learning.

Sputnik

Before the launch of Sputnik, Secretary of Health, Education, and Welfare, Marlon Folsom, stated that President Dwight Eisenhower considered a plan to improve mathematics and science in the United States (Wagner, 2006). During the Cold War, in 1957, the Russians launched Sputnik, and U.S. citizens became determined to improve mathematical education (Damms, 2002). Sputnik occurred when U.S. citizens were apprehensive about mathematical education (Dickson, 2004) and was credited with reopening the debate of public schools in the Soviet Union and in the United States (Damms, 2002). To win the Cold War, emphasis was placed on improving mathematics, science, engineering, and foreign language. First, the United States supported research and trained scientists by establishing the National Science Foundation and decreased support to New Math (Klein, 2003). The foundation supported and developed new mathematics and science curriculums in public schools. The curriculums were created to produce knowledgeable citizens to create and maintain defense technology against other countries (Johanningmeier, 2010). The U.S. government continuously supported scientific research and identified the need for gifted education in public schools. Future gifted education would identify and prepare K – 12 students to become scientists, mathematicians, and engineers (Jonanningmeier, 2010). After the Cold War, the United States was able to identify how far the educational system was behind other countries' educational systems (Jonanningmeier, 2010). Because of Sputnik, public school curriculums were revised by different academic scholars (Elam, 1964; Jenkins, 1961).

Great Society

In the mid-1960s, President Lyndon B. Johnson developed an idea of a "Great Society". The presidential vision addressed issues of the society pertaining to civil rights, education, poverty, economic inequities, health care, housing, and jobs (Levitan & Taggart, 1976). To tackle the issues of poverty and education, Title I was created through the Elementary and Secondary Act of 1965 (Bartell et al., 2015). The act was constructed to improve educational opportunities for disadvantaged students. Wong and Nicotera (2004) stated that Title I provided financial resources to school districts in poverty-stricken areas. Congress implemented different acts to decrease the issues that were associated with civil rights. First, the Civil Rights Act of 1964 made discrimination against jobs and segregated public facilities illegal. Next, the Voting Rights Act of 1965 was created to eliminate the use of poll taxes, literacy tests, and qualification tests that decreased opportunities for citizens to vote. Then, the Civil Rights Act of 1968 was created to eliminate discrimination against housing and protected Native Americans. The different acts were voted on by Congress as an effort to progress toward a Great Society (Bartell et al., 2015).

Coleman Report

In 1966, during the New Math reform, the Coleman Report was written. The Coleman Report explained that school resources were not effective in increasing student achievement and educational outcomes were dependent on students' background and economic status (Coleman et al., 1966). Bartell et al. (2015) stated that the Coleman Report increased educational funding and identified different ways that President Johnson could impact student achievement. For example, the report recognized peer background and interactions affected student achievement. Bartell et al. described the report as an Equality of Educational Opportunity and identified reasons why the New Math reform failed to impact education. One terminating factor was the year of the reform. Tate (2000) stated that the reformed curriculum was implemented when some schools were segregated and did not address the needs of neglected students. The reform focused on identifying the best and brightest students and ignored the needs of struggling learners (Bartell et al., 2015). Another problem identified with the reform was a lack of professional development for teachers. With the absence of professional development, teachers did not understand the curriculum or how to teach the content. Wong and Nicotera (2004) interpreted the findings as African American student achievement would improve if more Caucasian students were included in the classrooms.

Back to Basics

When the National Science Foundation decreased funding for the New Math reform, educational leaders called for "back to basics", and the previous math reform was discontinued. The purpose of the back to basics shift was to implement achievement tests, categorize student knowledge, and address shortcomings of the New Math reform. Burrill

(2001) stated that the back to basics mathematical movement was issued to close the achievement gap. During the movement, teachers taught basic mathematical skills and procedures (Resnick, 1980; Tate, 2000), increased testing was used to identify what content was taught to students, and calculators and computers were recommended in mathematical instruction (National Council of Teachers of Mathematics, 1970). Data from the tests displayed basic mathematical skills improved for marginalized students, but levels of cognition and understanding did not improve (Tate, 2000). Fey and Graeber (2003) stated that the back to basics movement influenced textbook development, teaching practices, and student assessment.

National Assessment of Educational Progress

In October of 1969, the National Assessment of Educational Progress (NAEP) was created when the U.S. Office of Education (USOE) awarded a $2 million grant to the Education Commission of the States to aid with organizing and forming initial assessments (Bourque, 2009). The NAEP was created by the U.S. Commissioner of Education, Francis Keppel, to provide an annual report of the progress of U.S. education (Bourque, 2009). During the 1960s and 1970s, development of the NAEP was slow due to financial, domestic, and administrative issues (Bourque, 2009). In the spring of 1963, private funding from Carnegie and Ford Foundations encouraged and supported the initial planning phases of the NAEP. Originally, President Nixon proposed $7 million to fund the assessment, but the U.S. Congress agreed to spend only $3 million. The measurement was a national representation of how U.S. students performed across various academic subjects (Bourque, 2009) and monitored students' knowledge, skills, and performance in Grades 4, 8, and 12 (Kessinger, 2011). In September of 1973, funding for the NAEP assessment changed from grant resources to contract funded (Bourque, 2009). The Educational Testing Service received the contract, and a new framework was created by a New Design for a New Era.

The United States used the NAEP to compare student performance from one state to another state (Kessinger, 2011). States voluntarily participated in the NAEP to determine the level of student performance compared to other states. The NAEP was utilized in six different ways: 1) to measure if students were meeting state standards; 2) to display patterns of achievement in mathematics, science, reading, and writing; 3) to compare student data to different states; 4) identified the impact of reforms on student achievement; 5) to provide information about the U.S. public education system; and 6) to provide student performance data (Kessinger, 2011). The assessment was designed to protect the rights of states, sample students by age, and report results at local levels (Bourque, 2009).

Student Readiness

Peterson, Woessmann, Hanushek, and Lastra-Anadón (2011) conducted a study to determine if U.S. students were ready to compete mathematically against other countries. A mixed methods study, with matrix sampling, was used to identify if students were ready to compete. Matrix sampling limited the number of questions administered to participants to decrease the amount of time allotted to complete the assessment (Childs & Jaciw, 2002). Participants were Grade 8 students who volunteered to be included in the study. Peterson et al. (2011) stated that participants did not complete the entire test, and scores were grouped among students.

In the study, researchers analyzed the NAEP and Program for International Student Assessment (PISA) scores for the United States and six other countries. The NAEP assessment was created with standards based on the beliefs of what curriculum directors, educational leaders, and the public thought should be assessed (Peterson et al., 2011). In contrast, the PISA was not created with proficiency standards. The assessment measured student performance using a scale of 1 (lowest) to 6 (highest). When comparing the performance and proficiency of a Grade 8 student, a NAEP proficiency of moderate would be equivalent to a rating of 3 with the PISA assessment (Peterson et al., 2011).

Peterson et al. (2011) used the U.S. class of 2011 to analyze the NAEP proficiency standards. For mathematics, 32% of the Grade 8 students demonstrated proficiency. From these data, 22 countries performed significantly better than U.S. students. Korean students surpassed U.S. students by 26%, and Canadian students outperformed U.S. students by 18%. The researchers concluded that the measurements were not aligned. Peterson et al. determined that the NAEP achievement scores were set lower than the PISA achievement scores. Researchers from the study identified several implications. From the low achievement scores given for the NAEP, Peterson et al. implied that the leaders who created the assessment had low expectations for mathematical performance. Another implication identified by the researchers was to increase the proficiency in mathematics to increase the U.S. economy

A Nation at Risk Reform

In 1983, *A Nation at Risk: The Imperative for Education Reform* suggested that reform was necessary to compete with other countries that were outperforming U.S. citizens in commerce, industry, science, and technology (Bartell et al., 2015). As a reaction to the report, states reported algebra I was a required high school course for students to complete (Bartell et al., 2015). Between 1982 and 1992, more students completed advanced mathematics courses in high school (Raizen, McLead, & Rowe, 1997). Although mathematics enrollment increased, Porter, Kirst, Osthoff, Smithson, and Schneider (1993) stated that instructional learning methods were not changed to differentiate instruction for struggling learners. With this setback in education, policymakers and President George H. Bush called for national mathematical standards (Bartell et al., 2015).

No Child Left Behind

The U.S. Congress passed the No Child Left Behind law in 2001, and President George W. Bush signed the law in 2002 (Kessinger, 2011). The purpose of No Child Left Behind was to meet the needs of all learners, improve the U.S. student achievement on international testing, and close the achievement gaps (NCLB, 2002). By 2014, the Act required states to implement testing, collect data, hire qualified teachers, and ensure that all students were proficient learners (Bartell et al., 2015). During the No Child Left Behind era, low-performing student needs were minimally met, and the schools that predominantly served the students were identified as failing (Bartell et al., 2015). Failing schools were given monetary incentives because of low student achievement and the school's inability to employ highly qualified teachers (Ryan, 2004). The negative impressions of public schools led legislators to create options for school choice, vouchers, and charter schools (Bartell et al., 2015). Policymakers stated that No Child Left Behind was inconsistent with the adequate yearly progress goals and curriculum standards were necessary (Bartell et al., 2015).

Mathematical Standards

After the reforms and movements, the National Council of Teachers of Mathematics outlined the need to improve mathematical teaching and learning (National Council of Teachers of Mathematics, 1980). This document was identified as the Agenda for Action, which called for the addition of problem-solving skills, interpretation, and application in mathematics (National Council of Teachers of Mathematics, 1980). From this document, the first detailed recommendations for national standards in mathematics were identified in 1989 with the *Curriculum and Evaluation Standards for School Mathematics* (Lappan & Wanko, 2003). The inquiry-based standards were developed by mathematicians to address the low achievement scores in mathematics (Maccini & Gagnon, 2000). The National Council of Teachers of Mathematics (1989) stated that the purpose of the standards was to improve students' problem-solving skills and mathematical ability, to learn the value of mathematics, and to communicate mathematically. Kosko and Gao (2017) stated that the standards encouraged dialogue and writing to develop students' mathematical understanding.

Due to critics of the standards, a mathematical modification occurred to address mathematical content, pedagogical techniques, and student achievement. Bartell et al. (2015) identified the controversy between advocates for reform and supporters for a traditional math curriculum as "math wars". The purpose of the math wars was to inform critics that increased student achievement could impact the economy, technology, and science of the country. The reformers of the 1989 mathematical standards advocated for critical thinking approaches to be implemented in education and devalued the use of algorithms and memorization (Wright, 2012). The reformist thought that assessment should focus on how students demonstrated mathematical processes from the learned content (Wright, 2012). The traditionalists advocated for a conservative teaching approach for social effectiveness (Schoenfeld, 2004). The traditionalist also viewed assessments as essential for assessing recall and procedures using the same standardized tests (Wright, 2012). In 2000, the math wars contributed to the National Council of Teachers of Mathematics revision of standards (National Council of Teachers of Mathematics, 2000). The new standards, called the *Principles and Standards for School Mathematics*, used algorithms and fluency skills to teach the curriculum (Bartell et al., 2015) and were "a balanced view of teaching for understanding that pays adequate attention to both skills and problem solving" (Becker & Jacob, 2000, p. 536). The new standards also provided grade level expectations for communicating mathematics in classrooms (Kosko & Gao, 2017). The required content was more balanced with the *Principles and Standards for School Mathematics* than the *Curriculum and Evaluation Standards for School Mathematics* (Bartell et al., 2015). The National Council of Teachers of Mathematics (2000) suggested that the new standards would address all grade levels on how to communicate effectively and consolidate mathematical thinking, critique students' thinking, communicate using the mathematical standards, set learning goals for students, act as a resource for teachers, and guide the development of courses. The National Council of Teachers of Mathematics organized the *Principles and*

Standards for School Mathematics into four categories, which included mathematical principles, an overview of standards for pre-kindergarten through Grade 12, a detailed outline of content and process standards, and steps to accomplish a vision (National Council of Teachers of Mathematics, 2000). As stated by Bartell et al. (2015), the revised standards calmed the critics of the mathematical standards and ended the math wars.

Additional modifications to the standards occurred in 2010 when policymakers implemented Common Core State Standards and Common Core State Standards for Mathematics. The Common Core State Standards were created by governors, legislators, administrative leaders, teachers, and stakeholders. The governor, with the assistance of all group members, created a diagram of what students were expected to learn (CCSS Initiative, 2012). The mission of the standards was to prepare all students to be college and career ready to compete in the global economy (Bartell et al., 2015). The curriculum was focused on science topics and other content areas (NGA Center & CCSSO, 2010). The Common Core State Standards identified eight standards for mathematical practice for students to be able to perform (CCSSI, 2014). With the use of the eight standards of mathematical practice, process standards, and content standards, students in Grades 1 through 12 would explore the same content (Akkus, 2016). The five content standards provided information on what students should learn in mathematics (National Council of Teachers of Mathematics, 2000). The five process standards were created to highlight ways students could acquire and apply knowledge (National Council of Teachers of Mathematics, 2000). The standards of mathematical practice (i.e., problem-solving, reasoning, argumentation, modeling, tools, precision, structure, and regularity) were created with ideas from the process standards and strands of mathematical proficiency

(NRC, 2001). As identified by Gifford (2004), the Common Core State Standards could improve the value and uniformity of U.S. mathematical education.

Mathematical Curriculum in Georgia

Fromme (2018) recognized that educational standards taught in schools impacted student performance. Since the implementation of standards, Georgia's educational department has used four different curriculums (Fromme, 2018). The curriculums identified by the state of Georgia are the Quality Core Curriculum, the Georgia Performance Standards, the Common Core State Standards for Mathematics and English, and the Georgia Standards of Excellence for Mathematics. The first curriculum, Quality Core Curriculum, was created to identify what students should know and be able to do in each subject area (Smith, 2007). After 15 years of Georgia schools using the Quality Core Curriculum standards, Phi Delta Kappa conducted a review of the standards (Mallanda, 2011). Results from the audit identified that there were several problems with the curriculum. First, standards were not rigorous enough to improve student achievement. Another finding was that the standards contained numerous objectives for students to learn. The third finding from the audit indicated limited professional development to improve teacher understanding of the curriculum. Following the report of the audit, the State Board of Education requested that the Georgia Department of Education create a new curriculum (Mallanda, 2011).

In 2005, after the math wars and the failed Quality Core Curriculum, the Georgia Performance Standards curriculum was created (Mallanda, 2011; Smith, 2007). The Georgia Department of Education (2007) created curriculum using input from K – 12 educators, college professors, legislators, and stakeholders. The Georgia Performance

Standards curriculum was created using the Japanese mathematical framework and resembled the standard structure of North Carolina (Mallanda, 2011). The standards defined how students could demonstrate proficiency of understanding the content (Black, 2014). The Georgia Department of Education (2007) affirmed that the Georgia Performance Standards curriculum was created to increase the enrollment of students in advanced mathematics courses. Black (2014) also stated the Georgia Performance Standards curriculum identified expectations for improving student achievement for elementary and secondary students.

In 2000, with the passing of the House Bill 1187, the A+ Education Reform Act required public schools to administer the CRCT to all students in Grades 1 through 8 (Black, 2014). The test assessed student knowledge in the areas of reading, English, language arts, and mathematics to determine if students understood the content that was taught with the Georgia Performance Standards curriculum (Black, 2014). The Georgia Performance Standards curriculum contained four mathematical concepts to teach students. The sections, created by the Georgia Department of Education (n.d., p. 2), were "numbers and operations, measurement, geometry, algebra, and data analysis and probability". The process standards that are used in mathematics include problem solving, reasoning and proof, communication, connection, and representation (Ferrini-Mundy, 2000). The five process standards supported and promoted students' mathematical development (National Council of Teachers of Mathematics, 2000). Students who were supported in "speaking, writing, reading, and listening in mathematics classes reap dual benefits; they communicate to learn mathematics, and they learn to communicate mathematically" (National Council of Teachers of Mathematics, 2000, p.

60). As suggested by Pugalee (2001), communication should be a fundamental component in implementing a balanced and effective mathematics program.

Since the 1980s, performance-based standards were the focus of educational change and required students to achieve a minimum level of academic knowledge before passing to the next grade level (Sadovnik, O'Day, Bohrnstedt, & Borman, 2013). With the implementation of the Georgia Performance Standards curriculum, school performance was measured with three indicators of the adequate yearly progress. The measured indices were academic achievement, number of students completing the assessment, and a school selected indicator. The Georgia Department of Education (2010) stated that the academic performance measuring tool was the Criterion-Referenced Competency Test (CRCT).

The Common Core Standards for Mathematics were released in 2010 by the Council of Chief State School Officers and the National Governors Association for Best Practices (NGA Center & CCSSO, 2010). Georgia adopted the Common Core State Standards during the 2012 – 2013 school year (Cochrane & Cuevas, 2015). Rothman (2012) explained that the Common Core State Standards were a set of expectations of what students should learn in order to complete entry-level work in post-secondary education or workforce-training programs. The Common Core curriculum emphasized mathematical practices and set grade-precise standards. The Common Core was modeled after past attempts by the National Council of Teachers of Mathematics to convey the vision for mathematics and helped with the growth of state and local standards (National Council of Teachers of Mathematics, 2010).

After Common Core State Standards, Georgia reformed the educational standards by deleting the words "common core" and renaming the standards to the Georgia Standards of Excellence (Wakefield, 2017). The standards contained comparable content, but were modified and recoded, for the purpose of mandated testing (Wakefield, 2017). The standards were also rephrased, recoded, and improved for the purpose of analyzing and conveying student data (Wakefield, 2017). With the release of the new mathematical standards, the CRCT was replaced by the Georgia Milestones Assessment System (GMAS). The GMAS was a competency test that measured students' knowledge in English/language arts, reading comprehension, mathematics, social studies, and science (Chafin et al., 2015). Competency tests, as identified by Georgia Department of Education (2017), were performance-based tests designed to assess students' academic performance by measuring student knowledge and skills acquired from a specific curriculum.

Tracking Changes in State Standards, School Practices, and Student Achievement

In a quantitative study, Lee and Wu (2017) examined U.S. reading and mathematics standards before and after the implementation of Common Core State Standards. The standards were expected to impact student achievement positively throughout changes in the curriculum (Lee & Wu, 2017). For this change to happen, Lee and Wu (2017) determined that professional development should be provided to teachers and administrators on how to teach the new standards. The curriculum changes would create new material aligned to standards, revise assessment proficiency levels on evaluations, require professional development for educators, and hold teachers and administrators liable for student accomplishments (Achieve, 2013).

The purpose of the study was to analyze survey feedback on the alignment of Common Core State Standards. The quantitative study was conducted in two consecutive phases. In Phase 1, rigor of state standards was analyzed based on average inconsistency of the NAEP. Mathematics and reading standards for Grades 4 and 8 were compared to NAEP based proficiency rates. Lee and Wu (2017) used data from 2003, 2005, 2007, 2011, 2013, and 2015 NAEP results from the National Center for Educational Statistics. Assessment results and Common Core State Standards implementation stages were gathered from different states' division of education and the Common Core website (Lee & Wu, 2017). From the Common Core website, since 2012, mathematics and English language arts standards were adopted by 42 states, and the standards were implemented by 2015 (Lee & Wu, 2017). From 2011 to 2015, Lee and Wu (2017) reported that 10 states implemented the new standards for one year, 26 states implemented the standards for two years, five states implemented the standards for three years, and one state implemented the standards for four years. To analyze the rigor of state standards from 2011 to 2015, Lee and Wu used a hierarchical linear model to determine the composite index rigor for each subject/grade.

In Phase 2, a regression model and an autoregressive cross-lagged path analysis were conducted to examine the relationship between state standards, school procedures, and student achievement (Lee & Wu, 2017). NAEP school administration survey was administered every two years from 2009 to 2015. From the analysis, Lee and Wu (2017) identified that the data displayed a strong correlation between program alignment with Common Core State Standards (i.e., $r = .78$ to $r = .89$) and alignment with assessments (i.e., $r =.82$ to $r = .93$).

Results from the analyzed data indicated that the rigor of state standards represented a wavy curve from 2003 to 2015. The curve indicated a steady drop in rigor with proficiency standards from 2003 to 2009 and a recovery from 2009 to 2013. Cronin et al. (2007) and Lee (2008) identified the average gain in rigor of proficiency standards from 2009 to 2015 as moderate to large (i.e., 1 point in logit, equivalent to 0.6 standard deviation unit). Lee and Wu (2017) acknowledged that several states received conclusive improvements (i.e., more than 1 standard deviation), and some states obtained no or marginally adverse gains. The limitations to the study involved implementing and using the Common Core State Standards practices. The results from the quantitative data indicated that the Common Core State Standards improved performance standards but did not increase student academic performance.

Teacher Perceptions of Common Core State Standards

Cochrane and Cuevas (2015) conducted a quantitative study to discover teacher perceptions of Common Core Performance Standards. The study aimed to identify teacher perceptions on high stakes testing, Common Core Georgia Performance Standards, student readiness for college, teacher workload, No Child Left Behind, and teacher morale. The study also aimed to determine if there was a relationship between teacher characteristics and views of Common Core Georgia Performance Standards. The participants in the study involved two north Georgia school districts. One district was considered a high-revenue county with 34,208 students and 2,168 teachers. In this school district, there were 34 schools (i.e., six high schools, nine middle schools, and 19 elementary schools). The demographics of the district included 76.77% Caucasian, 11.85% Hispanic, 5.99% Asian, and 2.34% African American (Cochran & Cuevas, 2015). From the student population, 14.6% were eligible for free lunch, and 3.7% were eligible for reduced priced lunch. The second school district was from a rural area. The district contained 3,502 students and 256 teachers (K – 12 School Rankings and Statistics, 2014). There were six schools within the district (i.e., one high school, two middle schools, and three elementary schools). The demographics of the district included 92.98% Caucasian, 5.37% Hispanic, 0.51% Asian, and 14% African American (Cochran & Cuevas, 2015). From the population of students, 33.9% were eligible for free lunch, and 8.9% qualified for reduced price lunch.

Cochrane and Cuevas (2015) conducted the study by creating a survey with Survey Monkey and sending the survey to principals. Next, principals agreed to send the survey to mathematics and English Language Art teachers. The survey included 26 questions, and participants answered the questions utilizing a five-point response scale (i.e., *strongly agree to strongly disagree*). Questions on the survey were related to teacher training, impact on education, teacher workload, teacher morale, and standardized testing. Additional questions on the survey contained demographic items, such as gender, teaching level, education level, teaching experience, and school rating.

From the two school districts, 75 responses were submitted, but five were incomplete and removed from the study. The demographics of the participants who submitted responses were 94.29% females and 5.71% males (Cochran & Cuevas, 2015). As identified by Cochran and Cuevas (2015), the participants included elementary teachers (75.71%), middle school teachers (18.57%), and secondary teachers (5.71%).

The results from the quantitative study yielded the mean and relationship between the different categories on the survey. The mean score for the first category, teacher training, was 3.08. Based on survey responses, 66% (*n* = 46) of the teachers considered professional development on the standards prepared educators to teach the content effectively to students, while 34% of the teachers claimed the professional development did not provide adequate preparation to teach the new standards. The mean score for the second category, impact of the new standards on education, was 2.94. The mean score represented the new standards did not represent a significant effect on NCLB, and teachers disagreed that the NCLB impacted student achievement. The teachers perceived that the new standards prepared students for college (45%, *n* = 31). From the responses, 43% of the teachers agreed that the new standards increased higher order and critical thinking skills. The final responses analyzed determined if students from the United States could develop academically at the same rate as students from other states. Based on the data, 49% of the teachers agreed that the new standards supported student achievement to maintain pace with other countries. The next category surveyed, teacher workload, obtained a mean score of 2.13. The mean score indicated that teacher workload was impacted directly by the new standards. The majority of the teachers (86%) implied that the new standards caused revisions to the lesson plans and how the content was taught, and 78% responded that more time was used to comply with standards than teaching the new standards (Cochran & Cuevas, 2015).

Cochrane and Cuevas (2015) analyzed teacher morale from the survey responses. The mean for this category was 2.46, which represented the new standards did not improve teacher morale. One question from the category identified that 69% of the teachers did not recognize more professional learning was provided for the new standards. Another question in the category indicated that 57% of the teachers agreed the new standards limited creativity and instructional strategies to teach students. Responses from the third question in the category identified that 77% of the teachers wanted more control over what content was taught to students than the new standards provided, and 69% of the teachers indicated there was no teacher voice to impact teacher reform. The final category was standardized testing, which resulted with a mean score of 3.93. The score symbolized that teachers did not approve of mandated testing. As compared to No Child Left Behind, 79% of the teachers did not experience less pressure with the new standards. Survey responses revealed that 77% of the teachers indicated too much time was spent on preparing students for high stakes tests instead of teaching the content. Finally, the survey results revealed that 83% of the teachers indicated the test was too long to complete.

To determine the relationship between teaching and education level, a Pearson *r* was conducted on school ratings, years of experience, and the impact of the new standards on education. A negative relationship existed between school rating and overall opinion of new standards impacting education ($r = -.24$; $p = .05$). Survey responses indicated that a higher school rating resulted in a lower teacher opinion of the new standards impacting education and that a lower rating created a higher teacher opinion about standards. Next, a positive relationship existed between degree of professional development and opinion of new standards impacting education ($r = .29$; $p = .02$). Responses revealed that, as teacher preparation increased, the higher the ratings were for standards. Next, teacher training and morale were compared, and a positive relationship was found ($r = .79$; $p < .001$). This correlation indicated that high morale educators responded with high scores for standards, and low morale teachers produced low scores for standards. The next relationship compared teacher workload and impact of standards on education. A positive correlation existed if a teacher contained a practicable workload ($r = .49$; $p < .001$). When teachers recorded higher ratings on standards, the scores indicated that teachers were not overworked, and, if teachers were overworked, low scores were assessed on standards. Next, teacher workload and morale yielded a positive correlation ($r = .64$; $p < .001$). When teachers negatively viewed workload, morale was low, and, when teachers positively viewed workload, morale was high (Cochran & Cuevas, 2015).

Teacher training, workload, and morale had positive relationships on rating the new standards for impacting education. When teachers were properly trained on how to teach the new standards, morale was high, and the new standards improved student achievement. From the survey data, teachers indicated that the new standards were a moderate improvement over No Child Left Behind standards. The limitations to the study consisted of principals sending out the survey to teachers, more women completed the survey, small sample size, and lack of generalizability to all schools. Future research, identified by Cochran and Cuevas (2015), consisted of increasing the sample size, including a heterogeneous population, and providing a sample population to eliminate the external validity of generalizability.

Below, in Table 1, researchers, Cochrane and Cuevas (2015) and Lee and Wu (2017), conducted quantitative studies by analyzing teacher perceptions on the impact of mathematical standards on student learning. From the two studies, Cochrane and Cuevas (2015) only used data from two schools in Georgia to gather information from teachers. In contrast, Lee and Wu (2017) gathered data from all of the states that implemented the new standards. From the results of the studies, teachers perceived the new standards improved student learning.

Table 1

Concept Analysis Chart for the Impact of Mathematical Standards and Teacher Perceptions

Study	Purpose	Participants	Design/Analysis	Outcomes
Cochrane & Cuevas (2015)	Identify teacher perception on high-stakes testing, Common Core Georgia Performance Standards and student readiness for college, teacher workload, NCLB, and teacher morale.	The participants from two north Georgia school districts.	Quantitative Survey	Teacher training, workload, and morale produced positive relationships on rating the new standards for impacting education.
Lee & Wu (2017)	The purpose of the study was to analyze survey feedback on the alignment of Common Core State Standards.	States that implemented the new standards.	Quantitative Autoregressive cross-lagged path analysis hierarchical linear model	The results indicated that the Common Core State Standards improved performance standards but did not increase student learning.

E-Learning Theoretical Framework

Technology is used to support humans by displaying the content in different ways (Goodyear & Retalis, 2010). With the use of technology, the internet is used as a communication tool for business, commerce, education, and public interactions (Yanti & Setiawan, 2018). The e-learning theory is student focused, accommodates for all learners, and contains different ideas, concepts, and content for students to learn (Murphy, 1997; Treffers, 1987). E-learning is instruction that is retrieved through electronic media, such as the “internet, extranets, satellite broadcast, audio/video tapes, interactive TV, and CD-ROM” (Govindasamy, 2001, p. 288). Rüth and Kaspar (2017) acknowledged the e-learning theory as utilizing information and communication technology to improve knowledge. The e-learning theory derives from the constructivism and connectivism theories (Rüth & Kaspar, 2017). Connectivism combines different ideas and sources of information to create learning (Rüth & Kaspar, 2017). Koohang, Riley, and Smith (2009) defined the constructivism learning theory as creating knowledge based on learners’ past experiences.

In the digital age, Gravemeyer, Stephen, Julie, Lin, and Ohtani (2017) stated that new approaches to teaching mathematics were necessary. New approaches to teach mathematics could be displayed with technology. The new methods to teach mathematics could contain elements from the e-learning theory. Aparicio et al. (2016) identified that the e-learning theory involves learning and technology, and the ultimate users of e-learning systems are students and educators. The e-learning theory, as identified by Oliver and Herrington (2003), is composed of three elements, which include resources (i.e., technology), support (i.e., people), and activities (i.e., services). Dabbagh (2005) stated that the three elements of e-learning consists of “learning technologies, instructional strategies, and pedagogical models (p. 299).

Aparicio et al. (2016) stated that the use of technology, with different learning strategies and methods, is used to enhance student learning. The e-learning theory is used with a computer-managed instruction (e.g., i-Ready) to provide mathematical interventions. Participants in the study, including students and teachers, used the program to increase student engagement, decrease learning gaps, and increase student achievement. To implement the services, teachers received professional development to teach students. The professional development was provided to inform teachers how to implement the software and additional resources in the classrooms.

Traditional Mathematical Interventions

Direct instruction involves clear directions and demonstrations of concepts by teachers (Ziegler & Stern, 2016). Richland, Zur, and Holyoak (2007) stated that direct instruction is effective when teachers provide cues to students. Researchers, Hattie (2009) and Kirschner, Sweller, and Clark (2006), agreed that teachers discredited direct instruction, but policy makers and administrators perceive this form of teaching is an effective way to communicate content.

Ziegler and Stern (2016) conducted a quantitative study to determine the effect of direct instruction on student mathematical achievement. The researchers used a 2x3 mixed factorial design to investigate the effects of learning algebra. The participants in the study consisted of 98 Grade 6 males (n = 51) and females (n = 47) from urban and suburban public schools in Zurich, Switzerland. The criteria to be included in the study was knowledge of the German language, no special learning needs, and minimum standards of the school's academic performance. Participants volunteered to be in the study and received a small gift.

The study contained a control group (n = 46), and an experimental group (n = 45). Participants in both groups completed four training sessions with a duration of 90 minutes each and three follow-up sessions. During the training sessions, participants received blackboard instructions and completed a learning assessment. The blackboard instructions consisted of addition and multiplication steps. Participants in the experimental group simultaneously completed addition and multiplication problems. In the group lessons, teachers asked questions, provided explanations to students, and gave hints to achieve the correct answers. The purpose of the teachers' feedback was to prompt students to identify similarities and differences among the operations. When a skill was mastered, the possibility of confusing operations was decreased. In the control group, participants completed two days of addition practice problems followed by two days of multiplication practice questions. During instruction, the teacher identified which elements to focus on in the problems and provided feedback on how to describe solutions and solve problems (Ziegler & Stern, 2016).

After the study, researchers conducted mixed-factorial analysis of variances (ANOVAs) on transformational knowledge and explicit transformation knowledge. A statistically significant difference, $F(1, 86) = 35.98$, $p < .001$, $\eta = .30$, with observed transformation of knowledge was found. Participants in the experimental group made less errors than control group participants with completing mathematical problems. When explicit transformation knowledge was analyzed, a statistically significant difference, $F(1, 84) = 10.29$, $p = .001$, $\eta = .11$, was found between the groups. Experimental group participants were able to write clear directions (i.e., steps) for how to solve a problem. Next, researchers used a multivariate analysis of variance (MANOVA) to determine the effect of student learning. A statistically significant difference, $F(2, 87) = 10.45$, $p < .001$, $\eta = .19$, was found with the experimental group's long-term knowledge. The experimental group also had statistically significant effects on the repetition tests, $F(1, 88) = 9.14$, $p = .003$, $\eta = .09$, and learning tests, $F(1, 88) = 20.36$, $p < .001$, $\eta = .19$ (Ziegler & Stern, 2016).

Ziegler and Stern (2016) identified implications, limitations, and suggestions for future research. One implication identified by the researchers was combining different types of mathematical problems could impede student learning. The researchers identified two limitations of the study. First, the order of the problems changed with the groups and limited the use of identical instructions. The next limitation was the research leader administered the blackboard instruction training. Ziegler and Stern identified two suggestions for future research for the study. First, a study could be used to determine if textbooks were needed to introduce similar concepts. Finally, future research could determine if the length of time to teach comparison or sequenced lessons would impact student learning.

E-Learning Frameworks

Gregor, Martin, Fernandez, Stern, and Vitale (2006) defined a framework as classifying factors in data system expansion that connects with the development of procedures. Dabbagh (2015) and Oliver and Herrington (2003) described the different factors in the e-learning framework. Dabbagh (2005) determined that pedagogical models are the groundwork of the e-learning theory. The five instructional models include open learning, distributed learning, learning communities, communities of practice, and knowledge building communities (Aparicio et al., 2016). These models are identified as processes that link the e-learning theory to e-learning practices (Dabbagh, 2005). The first model, open learning paradigm, consists of learning from a training, conference, or a distance learning course (Aparicio et al., 2016). The next model, distributed learning, is the process of individuals learning through technology (Dabbagh, 2005). The third model, learning communities, occurs in universities where students “tend to feel more self-confident and to feel supported by peers, instructors, and the college" (Patterson, 2011, p. 20). The fourth pedagogical model, communities of practice, are informal groups that share mutual concentrations, and collaborate ideas on academic ideas and business (Wenger, 1999). Liu, Chen, Sun, Wible, and Kuo (2010) stated that the communities tend to conduct regular face-to-face or virtual meetings. The final model, knowledge of building communities, is a group with "commitment among its members to invest their resources in the collective upgrading of knowledge" (Hewitt & Scardamalia, 1998, p. 82). The attributes of the pedagogical models are learning in a social process, learning with collaborative groups and distance learning, and utilizing time and space to individualize learning (Aparicio et al., 2016).

Another element from Dabbagh's (2005) framework was different instructional strategies. Aparicio et al. (2016) characterized the instructional strategies as teamwork, expression, contemplation, and imagination. Jonassen, Grabinger, and Harris (1997) stated that instructional strategies are used to increase student engagement. The final element of Dabbagh (2005) framework was learning technologies. Several researchers, McLoughlin and Oliver (1999), Rourke and Anderson (2002), Oliver and Herrington (2003), Dabbagh (2005), and Hsieh and Cho (2011), explained that e-learning technologies support learning in collaborative learning environments.

Other researchers, such as Oliver and Herrington (2003), identified three elements of e-learning. The researchers created a diagram to identify the different components of the e-learning theory. Oliver and Herrington (2003) agreed that the components are resources (people), support (technologies), and activities (services). This framework contained an abstract overview from research on components of e-learning (Carroll &

Swatman, 2000; Lee & Baskerville, 2003). In the framework, people involved in the e-learning system are customers, suppliers, professional associations, and board members. People network with e-learning systems by using technology. Services that are supported by e-learning are different instructional strategies to help students learn. The technology provides uninterrupted or unplanned communication with different people to collaborate, communicate, or integrate content knowledge (Aparicio et al., 2016).

Use of E-Learning Theoretical Framework

Aparicio et al. (2016) stated that e-learning systems combine various tools, such as writing equipment, communication technologies, abstract thinking, and data storage, to assist in student learning. In a qualitative study, Unianu and Purcaru (2014) conducted research to identify student perceptions regarding e-learning platforms. The results from the study concluded that students benefited from immediate feedback on assignments, communicating with peers, and access to other digital resources. In other studies conducted by Camilleri and Camilleri (2017) and Vate-U-Lan (2017), researchers used the e-learning theory to determine if digital games impacted student learning or perceptions. The results from these studies indicated that the use of the e-learning theory produced significant benefits on student learning.

Camilleri and Camilleri (2017) conducted a qualitative study to determine students' perceptions of using digital games in classrooms. Researchers used purposive sampling to select 41 participants from 10 schools in northern harbor Malta. The participants were selected from upper- and middle-class families in the school districts. The researchers used conversational interviews to identify students' perceptions and to discover if students considered digital games as a strategic tool that encouraged motivation and learning (Camilleri & Camilleri, 2017). During the interviews, memos were created or recorded to document the participants' responses. To analyze the qualitative data, the researchers used NVivo's coding software to explore printed and audible data.

From the qualitative software, recurring themes were identified and analyzed. The first theme was internet usage in education. Participants perceived that digital games were used for formative assessments and collaborative tasks. The use of applications improved student engagement on assessments, provided valuable feedback, and promoted collaboration among peers. The second theme was the use of educational applications. Results indicated that participants' learning and digital skills, interpersonal and social skills, critical thinking, and problem-solving skills improved. The limitations of the study were lack of uniformity to describe educational technology to compare literature, use of purposive sampling, sample size, research design, methodology, and type of analysis. Researchers, Camilleri and Camilleri (2017), suggested future research to investigate the impact of digital games on motivation and the long-term effects of digital learning resources.

Vate-U-Lan (2017) also conducted a study with the e-learning theory to determine if computer games impacted males or females. The purpose of the study was to identify the differences in attitudes of males and females toward playing e-learning games. The researcher conducted a quantitative study with an internet-based survey with 803 participants from Thailand. Participants were selected with convenience and snowball sampling. The sample population contained females (61.2%) and males (38.8%) 11 to 20 years of age (36.8%, $n = 291$), 21 to 30 years of age (24.1%, $n = 191$), 31 to 40 years of age (16.3%, *n* = 129), 41 to 50 years of age (13.3%, *n* = 105), 51 to 60 years of age (8.5%, *n* = 67), and older than 61 years of age (1%, *n* = 8). The survey included questions about demographics, actual or virtual game activity, and perceptions toward computer games. A five-point Likert-type scale ranging from *strongly disagree* to *strongly agree* was used for eight questions, which identified participants' attitudes regarding playing computer games.

Of the 803 participants, only 784 survey responses were analyzed. One category, type of game activity, had no statistically significant difference between males (39.6%) and females (39.9%). From the survey, male participants (49.8%) preferred entertainment games more than females (48.9%) participants. The perceptions of educational games data displayed a small difference from females (15.6%) and males (14.2%), but no statistically significant difference was revealed. The independent *t*-test for anxiety on computer games displayed a statistically significant difference in gender. From the data, the researcher explained that females experienced higher anxiety levels toward playing a computer game regarding risks of eyestrain (*M* = 4.33) than males (*M* = 4.25). Higher anxiety levels of reduced social interaction were also experienced in females (*M* = 3.94) than in males (*M* = 3.84). When computer games were used to learn educational content, females (*M* = 3.75) experienced higher levels of anxiety than males (*M* = 3.54), and the interaction negatively affected academic achievement. The final anxiety analyzed toward playing a computer game was time management. From the survey results, no statistically significant difference was found for females (*M* = 3.12) and males (*M* = 3.11) when playing computer games for leisure. Next, student perceptions were analyzed, and female participants (*M* = 4.15) identified that computer games were more relaxing than male participants (*M* = 4.09; Vate-U-Lan, 2017).

Next, the perceptions of computers increasing literacy was analyzed. From the analyzed data, males (*M* = 3.87) achieved higher assessments than females (*M* = 3.81). The third category analyzed was whether computer games improved problem-solving skills. From the analyzed data, males (*M* = 3.93) perceived computer games impacted problem-solving skills more than females (*M* = 3.76). A statistically significant difference was found between gender and perceptions of whether games impacted problem-solving skills. The final category analyzed was computer games' influence on student collaboration. Females (*M* = 3.74) perceived that computer games influenced collaboration more than males (*M* = 3.63; Vate-U-Lan, 2017).

From the analyzed results, males perceived that computer games improved problem-solving skills and females experienced more anxiety playing computer games. Another conclusion from the analyzed data was the e-learning theory impacted student understanding of the content. As a result of the convenience sampling technique, external validity of generalization occurred. Vate-U-Lan (2017) suggested that additional studies could include games with entertaining presentations, utilize smart technology, and promote social collaboration.

Below, in Table 2, two studies used the e-learning theoretical framework to determine if games improved student learning. Vate-U-Lan (2017) used quantitative data to analyze Thailand participants' attitudes and perceptions with e-learning games. Camilleri and Camilleri (2017) analyzed qualitative data of students' perceptions from

Malta. The results of the studies identified that participants' problem solving and critical thinking skills improved after using e-learning games.

Table 2

Concept Analysis Chart for the Use of E-Learning Theoretical Framework

Study	Purpose	Participants	Design/Analysis	Outcomes
Vate-U-Lan (2017)	To identify if there was a gender gap between student attitudes and perceptions towards playing computer games using the e-learning theory.	803 children and adults from Thailand	Quantitative design Analyzed with independent *t* test	With males, computer games improved problem-solving skills. Females experienced more anxiety playing computer games.
Camilleri & Camilleri (2017)	To determine students' perceptions of using digital games in classrooms.	Purposive sampling 41 participants from 10 schools in northern harbor Malta	Qualitative study Interview NVivo's coding software	Digital skills and learning improved. Interpersonal and social skills improved. Critical thinking and problem-solving skills improved.

Effects of Using Educational Technology

Technology promotes change and influences teaching methods, instructional strategies, learning styles, and access to knowledge (Watson, 2001). Burbules and Callister (2000) determined that there were benefits and confines of using technology. The key to using technology is to identify the uses, who will use the technology, and the purpose of the technology (Burbules & Callister, 2000). Studies conducted by Mahmoudi et al. (2015) and Earle and Fraser (2017) indicated that educational software did not produce a statistically significant effect on mathematical achievement. From these studies, mathematical achievement was not impacted because the online resource was not supported by the states' standards, students lacked the knowledge to play computer games, and the study had small sample sizes. Lei and Zhao (2007) stated that administrators, teachers, and students could benefit from knowing the advantages and harmful uses of educational technology.

Mahmoudi et al. (2015) conducted a quasi-experimental study. Over five weeks, researchers examined the effect of computer games (i.e., Ocean Express) on speed, attention, and consistency of learning mathematics with four schools from Urmia City, with two randomly selected male classrooms. One male classroom was identified as the experimental group, and the second male classroom was the control group. Participants from both groups completed the pretest, posttest, an Intelligent Quotient (IQ) test, Toulouse-Pieron Attention Test, Learning Test, Learning Speed Test, and Learning Stability Test (Mahmoudi et al., 2015). During the study, the experimental group completed 10 Ocean Express lessons on the computer, which lasted for 45 minutes. The control group participants were taught mathematical lessons in a traditional classroom. In the traditional classroom, students used the assigned curriculum to learn mathematical content. After three additional weeks of receiving the intervention, all participants were administered the posttest.

The analysis of covariance (ANCOVA) was used to measure learning, attention, learning speed, and stability. The analyzed data from the study displayed no interaction between attention, speed, and consistency. A test of between-subjects' effects was analyzed on attention, speed, consistency, and stability. The *F* test displayed the experimental group experienced a statistically significant effect on attention scores (F = 210.83, p = .001) than control group participants. The experimental group's speed on mathematical calculation differed significantly (F = 15.26, p = .001) from control group participants. The results indicated that the intervention increased the attention and mathematical calculation of students. Although there were significant effects on the experimental groups' attention and speed, no effect (F = 1.17, p = 0.28) was identified on learning mathematics and stability (F = 2.15, p = 0.15). The experimental group did not produce significant effects on consistently learning mathematics. Limitations to the study consisted of the type of sample and lack of student knowledge to play computer games. Mahmoudi et al. (2015) suggested that another study could be conducted with females and utilize the game along with traditional teaching.

Another study conducted by Earle and Fraser (2017) analyzed the Florida Comprehensive Assessment Test, an educational software, to determine the effect on mathematical achievement. The mixed methods study was conducted in Miami, Florida with 914 general education students in Grades 6 through 8. The researchers conducted a 10-week study to evaluate the effectiveness of an online resource, Florida Comprehensive Achievement Test explorer. The program was created by Infinity Software of Tallahassee, Florida in 1994. The Florida Comprehensive Achievement Test explorer was aligned to Florida state standards for Grades 3 through 10 for mathematics and reading. Earle and Fraser stated that the program was designed to increase student motivation to learn by providing hints to answer questions and step-by-step guidance to learn the content from the problems. The researchers used the Test of Mathematics Related

Attitudes to measure students' attitudes towards mathematics. Earle and Fraser also used a pretest and posttest for the Technology-Rich Outcomes-Focused Learning Environment Inventory, which was a questionnaire to measure changes in the student learning environment using technology.

After monitoring and documenting student progress for 10 weeks on the explorer program, 24 students (i.e., nine male and 15 females) were interviewed based on achievement scores (i.e., high, low, and middle). Participants included students from Grade 7 (n = 3) and Grade 8 (n = 21). The interview questions were based on the quantitative assessments to determine how students perceived the teacher, how problems were solved, how students perceived working in collaborative groups, students' perceptions of working problems on computers, and if the Florida Comprehensive Achievement Test program affected students' attitudes toward mathematics (Earle & Fraser, 2017). Interviews were conducted for 7 to 12 minutes, and participants were invited to complete a questionnaire after the meeting. From the qualitative data, responses from participants were analyzed, and recurring themes were identified. Coded themes consisted of engagement, mathematical process, problem-solving process, collaboration, computers, and solving mathematical problems.

After analyzing the coded data, researchers concluded a negative relationship existed between the Florida Comprehensive Achievement Test program and student achievement. A MANOVA was conducted between pretest and posttest scores on learning environment and attitudes. The 10 learning scales, identified by Earle and Fraser (2017), were cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity, differentiation, computer usage, and attitudes of young adults. Earle and Fraser identified three levels for attitude (i.e., enjoyment, inquiry, and normality) from the learning scales. The ANOVA displayed statistically significant scores for teacher support ($F = 7.06$), involvement ($F = 11.22$), investigation ($F = 5.06$), task orientation ($F = 8.55$), cooperation ($F = 4.93$), equity ($F = 16.32$), differentiation ($F = 6.55$), computer usage ($F = 6.55$). From the collected data, the researchers determined that students' mathematical scale score increased in the areas of student involvement, investigation, assignment differentiation, and computer usage. A decrease from pretest to posttest scores occurred in the areas of teacher support, task orientation, cooperation among peers, and equity among other students. The pretest and posttest results from the Florida Comprehensive Achievement Test did not produce statistically significant gains on student achievement, and student perceptions regarding using computers to learn mathematics were negative. A limitation to the study was the online resource was not supported by the Florida standards. Earle and Fraser suggested that future research could be conducted to determine if the software affected student learning.

Another study conducted by Garneli et al. (2017) indicated that an educational game did not impact student learning. The mixed methods study contained 80 Grade 6 students (i.e., 53 males and 27 females) from a middle school in northwestern Greece. The purpose of the study was to determine the effects of a game (i.e., Gem Game) on students' performance and attitudes. The study also investigated different ways to assign learning games. The participants were divided randomly into four groups of 20 students to learn mathematics with three versions of a digital game. Before dividing the students into groups, each participant completed a pretest to examine student knowledge. The study was conducted in a gymnasium during a 1-hour block. Groups 1, 2, and 3 were the experimental groups (i.e., played the Gem Game) and Group 4 was the control group (i.e., received traditional learning). In Group 1, participants played a storytelling game, and Group 2 participants played the same storytelling game without the story. Participants in Group 3 changed different features of characters, but mathematical content was not altered. Group 4 participants used a traditional method of learning mathematics, by completing 30 problems on paper. After the experimental and control groups completed the learning activities, researchers administered a survey to assess students' perceptions and attitudes. The items on the questionnaire had a five-point response scale, ranging from *strongly disagree* to *strongly agree*. Following the questionnaire, semi-structured interviews were conducted with participants who volunteered, and a posttest was administered to all participants.

To analyze data from the study, researchers collected quantitative data from the Gem Game and used qualitative data to provide insight on the quantifiable discoveries. The Games-Howell post hoc test was used to analyze quantitative data on low-performing student perceptions and attitudes towards learning mathematics with a game. The test was used to determine the needs of students that required more mathematical practice. Garneli et al. (2017) identified that low-performing students required more mathematical practice and made more than two mistakes on the pretest. Results indicated that the participants who used coding in the game (i.e., Group 3) had a statistically significant effect on students' perceptions, but no effect was identified on students' attitudes. Results from the test also indicated that the low-achieving females in the control group performed better with the conventional method of learning. Another result indicated that the use of no story or coding features (i.e., Groups 2 and 3) impacted students' perceptions, but they did not impact students' attitudes. The result from the test also indicated that participants in Group 3 did not produce statistically significant effects on learning mathematics.

The qualitative data that were used to support quantitative findings included observation field notes, student interviews, and teacher discussions. From the field notes, a content analysis was conducted, and thought-provoking phrases were identified. Next, the researchers coded the interviews into three categories, which included students' motivation, attitudes towards learning mathematics, and mathematical processing skills (Garneli et al., 2017). Through observations, participants were engaged while playing the games. Male participants were focused on game completion and did not complain about the game. On the other hand, females who struggled with the game quit before completing the game. After analyzing the qualitative data, participants preferred repetition of learning activities to learn mathematics. Another result indicated that different interventions did not impact male participants learning, but students' attitudes were positive. Limitations to the study were controlled time with the game (i.e., 1 hour), small sample size, and unequal skill level of groups. Garneli et al. (2017) suggested that future research studies could increase social interactions between learners and learning practice could be involved in the game.

Below, in Table 3, three studies were analyzed to identify the effects of using educational technology or programs to learn mathematics. Researchers, Earle and Fraser (2016) and Garneli et al. (2017), conducted mixed methods studies with heterogeneous sample populations. In contrast, Mahmoudi et al. (2015) conducted a quantitative study with a homogeneous sample of male students. The participants were students in Grade 6 through 8 from different parts of the world. From the quantitative study, participants' attention and mathematical calculation speed increased, but no interaction was identified on consistency of learning mathematics. From Earle and Fraser's (2017) study, participants' mathematics scale score increased, but the educational game did not cause a statistically significant effect on student achievement. In the final study, Garneli et al. (2017) found that the control group participants (i.e., traditional learning) outperformed the experimental group on learning mathematics.

Table 3

Concept Analysis Chart for the Effects of Using Educational Technology

Study	Purpose	Participants	Design/ Analysis	Outcomes
Mahmoudi et al. (2015)	To determine the effect of computer games on speed, attention, and consistency of learning mathematics.	Four schools from Urmia City Two randomly selected male classes were selected for the study.	Quantitative Pretest/posttest ANCOVA	No interaction between attention, speed, and consistency. Increased the attention and mathematics calculation.
Earle & Fraser (2017)	To identify the effect of Florida Comprehensive Assessment Test program on learning mathematics.	914 general education students in Grade 6 through Grade 8	Mixed methods study MANOVA ANOVA	Students' mathematics scale scores increased in the areas of student involvement, investigation, assignment differentiation, and computer usage. No significant effect on student achievement, and student perception on using computers to learn mathematics.

Study	Purpose	Participants	Design/ Analysis	Outcomes
Garneli et al. (2017)	To determine the effects of a game on students' performance and attitudes and different ways of assigning learning games.	80 Grade 6 students (i.e., 53 males and 27 females) from a middle school in northwestern Greece	Mixed methods study Quantitative data from the Gem Game Games-Howell post hoc test Qualitative: interviews (i.e., teachers and students) Field notes	Low-achieving females in the control group performed better with the conventional method of learning. Not significant for students' attitudes. Participants preferred repetition of learning activities to learn mathematics. Different interventions did not impact male participants' learning, but students' attitudes were positive.

Gender and Educational Technology

Gender is recognized as an element that promotes cognitive abilities, such that males' comprehension improve more on movement tasks than females, and females' performance improve more on oral competence tests (Halpern et al., 2007; Ullman et al., 2008). Gender differences have been observed in communication style, use of linguistic elements and level of participation in face-to-face and computer-mediated communication settings (Fischer, 2011; Herring, 2000; Herring & Storger, 2014). Koulouri, Lauria, and Macredie (2017) acknowledged that gender generated a broad impact on computer skills and technology requirements. Chen and Macredie (2010) identified different ways (i.e., skills, implementation results, observations, and opinions) females and males networked with technology. Research from Koulouri et al. (2017) and Fairlie (2016) revealed gender differences in usage, preferences and perceptions in computer games, and virtual environments.

Koulouri et al. (2017) conducted an experimental study to identify the effect of visual feedback and gender dynamic on performance, perceptions, and communication strategies. Visual feedback enabled collaborators to monitor task conditions and activities of other participants. The study included 64 (i.e., 32 males and 32 females) undergraduate and postgraduate students from the University of Kentucky. To be included in the study, participants were required to have prior computer experience and knowledge of instant communication programs. Participants in the study were selected randomly to homogeneous and heterogeneous collaborating gender pairs (i.e., an instructor and a follower) to complete a course-plotting task. The task was created with a customized navigation system that supported interactive simulation and allowed real-time direct text transmission between the leader and follower. During the study, participants used the navigation system to complete six destinations, and data were recorded on each participant's actions and statements. From the data, researchers were able to understand how participants approached the task and any problems that developed.

Following each task, instructors completed a five-question survey to identify perceptions of the instructors. The questionnaire used a seven-point response scale (i.e., *strongly disagree, disagree, slightly disagree, neutral, slightly agree, agree,* and *strongly agree*) to identify how instructors perceived the completion of the task, accuracy, ease of use, helpfulness, and satisfaction. Researchers used a between-subject factorial design to investigate the collaboration effects of instructor's gender, follower's gender, and visual feedback on the performance-associated and communication-correlated dependent variables. The analyzed data from the navigation system identified a statistically significant effect of visual feedback on number of words per task [$F(1, 24) = 6.904$, $p = .015$, $\eta = .191$, $d = .94$]. Pairs in the no visual feedback condition ($M = 99.5$, $SD = 34.57$) required more words to complete each task than the visual feedback pairs ($M = 72.46$, $SD = 21.27$). During the no visual feedback session, all of the pairs used more words to complete the tasks. The gender of the instructor had a statistically significant effect on visual feedback [$F(1, 23) = 5.548$, $p = .027$, $\eta = .137$]. Female instructors led the visual feedback, with more than 61.9% of turns. The analysis also found a statistically significant effect with instructor's gender and feedback [$F(4, 80) = 2.750$, $p = .038$, $\eta = .084$]; male instructors observed improved task completion compared to female instructors. A three-way interaction effect of visual feedback by instructor's and follower's gender had a statistically significant difference between female-female pairs [$F(1, 24) = 4.381$, $p =.047$, $\eta =.126$]. The results from the statistical data indicated that males had a higher perception of the task than females, males used different words to communicate, and females communicated more than males during the tasks.

Researchers, Koulouri et al. (2017), identified implications, limitations, and suggestions for future research for the study. One implication was the collaborative software could be used in educational and office settings. Researchers also implied shared visual information, from the pairs, could replace the vocal directions in the tasks. An additional implication was the follower's verbal commands were repeated and disregarded by the instructor. A final implication was the software developers should implement different functions, such as pointers to corroborate joint responsiveness to objects. There were four limitations identified by the researchers. One limitation was generalizability because the results from the study were not associated with a specific location. Another limitation was the type of design. The experimental process caused knowledge irregularity for the instructors. The restraint was caused when the instructors were not aware of the human pair for the study. Investigational manipulation also occurred when the researchers used typed communication during the tasks. Another limitation of the study was the questionnaire was restricted only to instructors. Koulouri et al. (2017) identified suggestions for future recommendations for the study. One suggestion was to use a questionnaire targeted towards the usability, learning, perceptions, and cognitive demands of the program. Another suggestion was to replicate the study using two different ways (i.e., the instructor knows the collaborating person, and the instructor knows the gender of the partner).

Fairlie (2016) conducted a randomized control field experiment to examine the effect of computer use on disadvantaged males and females. The researcher selected 1,123 students in Grades 6 through 10 from 15 middle and high schools in California. The selected schools were comparable in size (i.e., 749 to 781 students) and female to male ratio (i.e., 1.02 to 1.05). Students at the schools also received free or reduced lunch (81%), and 73% to 82% of the students represented minorities. To identify the participants, an in-class survey was administered, and 24% of the 7,337 students reported no computers at home. From the survey results, 1,636 students did not have a home computer and were eligible for the study. To receive the computer, participants completed a baseline survey, and parental consent forms were to be submitted to the school. Applicable permission forms and questionnaires were completed by 1,123 (68.6%) of the students. The study contained 555 males and 568 females. From the identified participants, students were assigned randomly to the treatment (n = 559) and control (n = 564) groups. The treatment group contained 280 males and 279 females, and the control group contained 275 males and 289 females. Participants who were selected for the study achieved lower standardized test scores on mathematics (M = 3.1 compared to M = 3.3) and English-language Arts (M = 3.2 compared to M = 3.6).

The researcher collected data from four sources (i.e., starting point survey, continuance survey, administrative data, and standardized scores) to identify how the different genders performed on the STAR assessment and utilized computers. The baseline survey was administered before the distribution of computers and was analyzed with the Current Population Survey Computer and Internet Use Supplements survey. The Current Population Survey Computer and Internet Use Supplements survey examined family characteristics (i.e., race, income, and age). At the end of the school year, participants (i.e., 78.2% males and 76.6% females) completed follow-up survey questions about possession of a computer, time on homework, and assignment attempts. The survey was analyzed with Kaiser Family Foundation's time use of technology, and Pew Internet and American Life Project surveys of teenagers. The third data source was participants' grades and conduct. The final data source was STAR standardized scores (Fairlie, 2016).

From the results of the follow-up survey, computer use increased for males (i.e., 110 minutes per day) and females (i.e., 101 minutes per day). Computer ownership also increased for females (i.e., 82% of the treatment group and 27% of the control group) and males (i.e., 80% of the treatment group and 25% of the control group). Females spent more time on computers completing homework (*M* = 79%), social networking (*M* = 25 minutes), submitting emails (*M* = 18 minutes), and other communication activities (*M* = 12 minutes). In contrast, males spent more time playing games (*M* = 39%) and accessing videos and other enjoyment activities (*M* = 23 minutes). No statistically significant difference was found with standardized proficiency levels between males ($p = .05$) and females ($p = .05$). Results from the data sources indicated that home computer use did not statistically affect the amount of time males (*M* = 0.39) and females (*M* = 0.38) spent on homework, and the student achievement gap was not affected by computer usage (Fairlie, 2016).

Fairlie (2016) recognized implications and recommendations for future research on the study. One implication was females were more self-regulated than males. Although females completed more time on homework, the achievement on standardized testing did not differ significantly from males. The researcher also identified recommendations to improve the study. Future research could increase the number of male teachers at lower grade levels, have all-male classrooms, increase hands-on activities, and increase recess time for male students. Future research could also investigate the reasons for gender differences in learning outcomes.

E-Learning Systems

Computer-Based Instruction

Kulik and Kulik (1991) reported computer-based instruction was used in the 1960s to “drill, tutor, test, and manage instructional programs” (p. 75). Brayshaw and Gordon (2016) stated that the internet, interactive web, and use of an interactive program changed the delivery of computer-based instruction. Computer-based instruction contained directions that crossed with knowledge based on the users' prior answers. If the computer-based instruction identified that the user required additional practice on a skill, remediation content on that element could be delivered through the program (Brayshaw & Gordon, 2016).

Bevelier, Green, and Dye (2010) and Myers, Wang, Brownell, and Gagnon (2015) reported that educators preferred to use computer-based instruction to educate students. In educational settings, computer-based instruction is used to supplement teaching methods (Kulik & Kulik, 1991). Hannafin and Foshay (2008) conducted a case study with a computer-based instruction that was utilized in a remediation course. Results from Hannafin and Foshay's research demonstrated that computer-based instruction provided students more differentiated and face-to-face instruction. Participants in the study were Grade 10 ($N = 126$) students from a northeastern town. The treatment group contained 87 students, and the control group contained 39 students. Hannafin and Foshay used a repeated measures ANOVA to test whether gain scores were significantly different between Grade 8 and Grade 10 test scores. The researchers also used a Pearson Product Moment Correlation to examine the relationship between the computer-based instruction and Grade 10 test scores. Overall, student achievement increased significantly [$F(1, 124) = 108.64$, $p < .001$] from Grade 8 ($M = 221.5$) to Grade 10 ($M = 239.0$). The treatment group used Plato Learning Systems, a computer-based instruction, to remediate students' mathematical knowledge. The treatment group improved test scores from $M = 215.5$ to $M = 236.1$ compared to participants who did not use the computer-based instruction (i.e., $M = 234.2$ to $M = 245.4$).

Another study, conducted by Ke (2008), also used computer-based instruction in an educational setting. The researcher conducted an across-stage mixed methods study to determine the relationship between computer games (i.e., ASTRA EAGLE) and traditional learning. Participants in the study were 358 Grade 5 students from four school districts in central Pennsylvania. From the selected participants, 49% were females, 51% were males, and 38% were economically disadvantaged. The participants were divided randomly into six groups, including three control and three treatment groups (i.e., individual, competitive, and Teams Games Tournament). To analyze the quantitative data, a correlational analysis, one-way MANOVA, and a single MANCOVA were conducted. From the analyzed statistical measures, the computer-based instruction promoted positive attitudes towards mathematical learning [$F(1, 263) = 14.34$, $p < .001$], and the classroom structure significantly affected mathematical test performance [$F(2, 263) = 3.67$, $p < .05$]. Results from the MANOVA indicated no significant pre-treatment difference between experimental groups. Results from the MANCOVA indicated that mathematical achievement differed significantly for the experimental groups [$F(15, 789) = 2.66$, $p < .01$]. From the qualitative findings, the retention of content improved with computer-based instruction, mathematical performance did not improve, and mathematical cognitive skills did not improve.

Papastergiou (2009) conducted research on computer-based instruction. The researcher used a pretest/posttest experimental design to analyze two educational computer programs (i.e., LearnMem1 and LearnMem2). Participants included students from two randomly selected high schools (i.e., 46 males and 42 females) in Trikala. Papastergiou utilized three paper-based questionnaires to gather data for the study. From the data, a statistically significant difference [$F(1, 86) = 6.602$, $p = .012$] was found with the pretest between males ($M = 15.15$, $SD = 3.25$) and females ($M = 13.45$, $SD = 2.92$). The males demonstrated more background knowledge on computer memory than females on the Computer Memory Knowledge Test. When analyzing the Computer Memory Knowledge Test posttest scores, gender was not statistically significant for student achievement [$F(1, 83) = 2.519$, $p = .116$]. The study demonstrated that student knowledge and motivation were impacted by a digital learning game.

Butterworth and Laurillard (2010) conducted a mixed methods study on computer-based instruction (i.e., Dots2Track and Dots2Digits) with basic numerosity tasks. The purpose of the study was to identify the participants' learning difficulties, behavior on learning games, performance within the tasks, and how the intervention impacted achievement. Participants in the study were from the United Kingdom. Observations of participants utilizing the programs were recorded to evaluate the computer-based programs. Findings from Butterworth and Laurillard's study identified that teachers could provide more one-to-one assistance to students, participants could practice more with digital games, and student achievement could improve. The researchers analyzed accuracy when answering questions. From the analyzed data, the number of errors made by the treatment group was not significantly different from the control group [$F(1, 10) = 4.566$, $p = .058$]. Results from Butterworth and Laurillard's study provided support that computer-based instruction supported collaborative learning, modified lessons, and improved motivation for students. With the support that was offered by computer-based instruction, teachers were able to effectively teach mathematics (Butterworth & Laurillard, 2010; Ke, 2008; Papastergiou, 2009; Rubinsten & Tannock, 2010).

Duhon, House, and Stinnett (2012) identified four categories of computer-based instruction, which includes computer-Assisted, computer-simulated, computer-enriched, and computer-managed instruction. The computer-based instructional programs use computers to teach students educational content instead of utilizing only paper and pencil (i.e., traditional learning). With school systems, computer-assisted instructional programs support teaching students. Küçükalkan, Beyazsaçlı, and Öz (2019) stated that computer-simulated instruction is the use of computers to reproduce educational content. The use of game-like tests, learning activities, and games to allow students to learn and have fun is identified as computer-enriched instruction (Küçükalkan et al., 2019). The final category of computer-based instruction was computer-managed instruction. The different computer-based instructional programs supports teaching methods, offers feedback to students, presents opportunities to practice educational content, presents differentiated instruction, and provides teachers with the opportunity to monitor student progress (Burns, Kanive, & DeGrande, 2012). These programs allow teachers to assess student performance (Küçükalkan et al., 2019).

Computer-Assisted Instruction

Computer-assisted instruction was one type of computer-based instruction. Ewe, Njoku, and Alio (2017) determined that the use of computer-assisted instruction and internet technology transformed the delivery of educational content. Anthony and Abigail (2017) recognized two key items to implement computer-assisted instructional programs in school districts. First, teachers should understand the need for technology in classrooms to impact students. Next, computers are essential to provide students with the ability to access the computer-assisted instructional programs. Computers are utilized as tools to teach content by displaying images on the screen, and students use a keyboard to input answers (Ewe et al., 2017). Computer-assisted instruction allows teachers to use computers to deliver educational content to students (Koizumi & In'nami, 2013). Researchers, Liao and Lin (2016) and Ukoha and Eneogwe (1996), stated that computer-assisted instruction could be used as a teaching technique to enhance student learning and improve students' attitudes towards learning. Other researchers, such as Gulio (2011), Bahrani (2011), and Ewe et al. (2017), recognized that computer-assisted instruction is used to provide interactive lessons with drill and practice, step-by-step tutorials, simulated activities, differentiate student learning, and introduced new teaching methods. Bahrani (2011) also stated that computer-assisted instruction provides effective feedback to students.

Tienken and Maher (2008) conducted a quantitative, quasi-experimental study to investigate the effect of computer-assisted instruction on student achievement. The study was conducted with Grade 8 students from Central New Jersey and used the computer-assisted instructional program to drill and practice mathematical computation. The school consisted of 895 students in Grades 7 and 8. The school was classified as "need improvement" by the New Jersey Department of Education. Based on the mathematics' section of the New Jersey Grade Eight Proficiency Assessment, 55% of the Grade 8 students scored partially proficient (i.e., lowest of the three categories). According to Tienken and Maher (2008), if the school district failed to improve student achievement, restrictions would be placed on the school.

The study consisted of 284 Grade 8 students and four randomly assigned teachers. To select participants for the study, Tienken and Maher (2008) used a four-part criterion. First, participants were selected if they received a valid score on the mathematics section of the Grade 7 Terra Nova test. Next, participants had to receive a valid score on the mathematics section of the New Jersey Grade Eight Proficiency Assessment. Another criterion for students was attendance. Participants were required to be enrolled in the school during the entire Grade 7 and 8 years. The enrollment in regular education courses was the final criteria for participants. Students who were enrolled in special education programs or received individualized support were excluded from the study.

Participants in the study were assigned to the control group (n = 163) or experimental group (n = 121) based on mathematics pretest scores. The study was conducted in mathematics classrooms during the participants' scheduled period. In the control group, participants did not use the computer-assisted instructional program or websites to learn mathematical skills. Teachers in the control group used the New Jersey Core Curriculum Standards and the school's adopted mathematics curriculum to teach the students. In the experimental group, teachers used the computer-assisted instructional program for 20 weeks to provide drill and practice with basic mathematical skills. Students used the computer-assisted instructional program twice a week for 45 minutes to complete mathematical practice. After participants learned the arithmetical skills, with the computer-assisted instructional program, teachers allowed students to use a Microsoft presentation to create a book report. Participants created a digital report to display the content that was gained from using the computer-assisted instructional program. During the study, the district mathematics supervisor monitored teacher instruction in the control and experimental groups. The supervisor also checked lesson plans and helped experimental group teachers on accessing websites (Tienken & Maher, 2008).

Tienken and Maher (2008) used an ANOVA to identify factors associated with the success or failure of the New Jersey Grade Eight Proficiency Assessment mathematics test. The ANOVA compared the pretest scores of the control group students to the Grade Eight Proficiency Assessment. The statistical analysis was used to determine the interaction between different factors. The factors analyzed in the study were ethnicity, socioeconomic status, and pretest scores. From the analyzed ANOVA and Grade Eight Proficiency Assessment data, control group participants produced statistically significant ($p < .05$) gains compared to the experimental group.

One set of factors was the interaction between the different ethnic groups within the study. In the control group, Asian/Pacific Islanders performed higher than the other groups on the Grade Eight Proficiency Assessment. The data from the ANOVA did not display a statistically significant difference ($p < .05$) between African Americans and the Hispanic/Latino groups. In the experimental group, a statistically significant ($p < .05$) difference was found between the ethnic groups on the mathematics test, but the different ethnic groups did not have statistically significant gains on the mathematics assessment. Tienken and Maher (2008) also analyzed the interaction of the computer-assisted instructional program on ethnic groups. In the experimental group, Asian/Pacific Islander participants displayed statistically significant ($p < .05$) gains on the program compared to other ethnic group participants. Control group participants who scored in the lowest percentile on the pretest performed better on the Grade Eight Proficiency Assessment than the participants in the experimental groups. The analyzed data indicated that the computer-assisted instructional program negatively affected all ethnic groups' achievement on the Grade Eight Proficiency Assessment mathematics test.

Tienken and Maher (2008) identified limitations, implications, and suggestions for future research for the study. One limitation was the small sample size of teachers utilized in the study. Only four teachers were used in the study. Another limitation was generalizability. Results of the study could only be generalized to schools that contained similar demographic and socioeconomic status. A final limitation to the study was the type of analyzed data. The results did not demonstrate a cause-and-effect relationship between the computer-assisted instructional program and student achievement. An implication identified by Tienken and Maher was to utilize the program to teach mathematics using problem solving and critical thinking skills. Tienken and Maher also implied that the computer-assisted instructional program negatively affected academically struggling students' mathematical skills. Suggestions for future research were not identified by Tienken and Maher, but advice was provided to administrators on how to select appropriate computer-assisted instructional programs.

Chappell, Arnold, Nunnery, and Grant (2015) conducted a mixed methods study with a computer-assisted tutoring program. The purpose of the study was to determine the impact of an online tutorial program on students receiving mathematical intervention. Participants (n = 119) were from two rural middle schools from southern Virginia (i.e., School 1) and central Kansas (i.e., School 2). The targeted participants for the study were middle school students who struggled to learn mathematics and received Tier II and III responses to intervention services. Participants in School 1 consisted of Grade 6 (n = 69) students. Participants attended an average of 28 tutorial sessions (i.e., 14 hours) that lasted for 30 minutes. During the intervention sessions, 60 tutors provided intervention services to students in the experimental group. Selected tutors were required to have a four-year degree and two years of teaching or tutorial experience. On average, six tutors worked with each student. In School 2, Grade 7 and 8 (n = 70) students participated in the study. Participants in the study completed an average of 38 tutoring sessions (i.e., 23 hours) that lasted for 37 minutes. Sixty-one tutors provided intervention services to students with the tutorial program.

Experimental groups utilized Focus Edu Vision, an online tutoring program to learn mathematical skills. The program was an interactive computer-assisted instruction that occurred simultaneously with assistance from tutors. Before participants started using the tutorial program, a pretest was administered. Participants from both schools were removed from mathematics classrooms twice a week to complete the intervention. Instructors and participants used the software to chat with instant messages and completed assignments with interactive whiteboards (Chappell et al., 2015).

To analyze the effect of the intervention program, researchers used a paired samples t-test and an ANCOVA. Participants in School 1 scored below proficiency on the pretest for the Virginia Standards of Learning assessment (M = 383.08). The cut score to demonstrate proficiency on the Virginia assessment was above 400 (Virginia Department of Education, 2012). Like School 1, participants in School 2 did not achieve a high score on the pretest (M = 26.87). After the tutorial intervention, participants in School 1 completed a posttest with the Standards of Learning. Thirty participants (61.2%) obtained a passing score on the assessment, and the mean score on the posttest was above proficiency (M = 405.96). A within-group analysis of the participants' pretest and posttest means displayed improvement. The mean score was 22.88 points ($t = 5.99$, $p < .001$) with an effect size of $d = +0.95$. In School 2, participants completed the posttest using a computer program assessment. Fifteen participants (30%) achieved a high score on the posttest. The experimental group participants obtained posttest scores lower than the achievement level ($M = 53.03$), but student achievement increased. The within-group analysis of the mean scores improved by 26.16 points ($t = 10.11$, $p < .001$) with an effect size of $d = +1.47$. After the within-group analysis, a between group analysis was conducted with data from School 1. The analysis was conducted with an experimental ($n = 49$) and a control group ($n = 292$) of Grade 6 students. Using the ANCOVA, the control group mean score decreased, and the between-group posttest scores of the two groups did not display a statistically significant difference, $F(1, 66) = 1.144$, $p = .20$ (Chappell et al., 2015).

Chappell et al. (2015) identified implications and limitations for the mixed methods study. There were two limitations in the study. First, the participants were not selected randomly for the experimental groups. Another limitation was the issue of generalizability. The results were limited to schools that contained low-performing students in a rural district. One implication in the study was prompts could be utilized in the tutorial program to provide students an opportunity to reflect on learning. Chappell et al. implied that the tutoring program could increase student engagement to improve achievement.

Roschelle, Feng, and Murphy (2016) conducted educational research on a computer-assisted instructional program. The researchers conducted a quantitative study to determine if online mathematics homework increased student achievement. The researchers used ASSISTments as an intervention program and teacher trainings to impact low-performing students. All students received the intervention, and the program was designed to impact each learner (Roschelle et al., 2016). Ritter, Anderson, Koedinger, and Corbett (2007) stated that ASSISTments provided students with immediate feedback and was comparable with a reasoning tutor program.

The quantitative study was conducted with 46 middle schools in Maine. The schools were recruited using mailings, live webinar presentations, news broadcasts, personal communications, and school visits. After the different recruitment methods, interested schools completed an application and were accepted into the study. Once the schools were identified, the schools were assigned as pairs randomly. The sets of schools were created based on Grade 6 New England Common Assessment Program mathematical scores and school size. During the study, three schools dropped from the study, which resulted in 43 participating schools. The final sample contained 40 paired schools, with three schools assigned to the treatment ($n = 2$) and control ($n = 1$) groups. From the middle schools, the study was conducted with Grade 7 students. The total sample size was 2,850 participants, which included 1,621 students in the treatment groups and 1,229 students in the control groups. The effect size of the treatment group was $g = .18$. Participation was distributed equally between males (49.3%) and females (50.7%). The demographical data for the sample included Caucasians (92.6%), African Americans and Hispanics (2%), Asians (1.8%), and multiethnic (1.5%). The participants also included students classified as receiving free/reduced lunch (38.7%) and special education services (12.2%; Roschelle et al., 2016).

Roschelle et al. (2016) indicated that the treatment and control groups were created with schools that did not pair with other schools on test scores or size. The researchers used the delayed treatment design to conduct the study. Participants in the treatment groups used the ASSISTments intervention to complete mathematics homework, and teachers received training and coaching on the program. Teachers received professional development for three days in the summer and continued training throughout the school year. During the school year training (i.e., in person and online), program coaches assisted teachers with implementing and assessing student knowledge. Participants in the control groups did not use the intervention to complete homework, and teachers did not receive the training during the study. After two years, all teachers received the intervention training and used the ASSISTments program.

To determine if the intervention impacted student achievement, the Terra Nova test was administered at the end of the school year to all participants. The test measured student knowledge on mathematical thinking, procedures, and abilities. Roschelle et al. (2016) also gathered ASSISTments data (i.e., student and teacher usage) from the program. Researchers used the hierarchical linear regression model to analyze student-level predictors (i.e., mathematics scores, free/reduced lunch status, and IEP status) and school-level variables (i.e., New England Common Assessment Program and school pairs). The New England Common Assessment Program was a test that included data for students' reading and mathematics scores, demographic information, and IEP status (Roschelle et al., 2016). The treatment groups' Terra Nova adjusted mean score was 690.79, and the control groups' mean score was 681.95. A statistically significant difference, $t(20) = 2.992$, $p = .007$, was found between the treatment and control groups' adjusted mean score. The average Terra Nova score of the low achievement treatment group participants was 13.35 points higher than the low achievement control group participants. The above average treatment group participants scored higher than the median score on the mathematics scores and improved by an average 5.84 points higher than the above average control group participants. The mean score for the intervention group was statistically significant, $t(2770) = 2.432$, $p = .15$, for low-achieving learners compared to the participants with high-achievement (Roschelle et al., 2016).

The study also contained implications, limitations, and suggestions for future research. One implication identified by the researchers was the effect size ($g = .18$) of the treatment group could improve student growth from the 50th to 58th percentile. Another implication identified by Roschelle et al. (2016), was high-achieving students did well on mathematics homework without support. The researchers also identified three limitations from the study. First, the study could not be generalized to different populations. Individual participants in the study were provided laptops, and, if other schools did not provide technological devices to students, the effect size could decrease. Another limitation was the location of the study. Maine is in a rural and homogeneous area and the results were limited to this type of population. The final limitation was the amount of time the teacher participants were given to implement the program. The participants were given one year to learn and implement the intervention. Roschelle et al. suggested that the study could be changed to a mixed methods design. With this design, data could be collected from interviews, surveys, and ASSISTments' logs to identify the impact of the program on student and teacher learning.

Kelly and Rutherford (2017) used another computer-assisted instructional program to conduct research. The researchers used Khan Academy, an open educational resource that provided free online mathematics resources (Kelly & Rutherford, 2017). The materials that were provided by the online platform could include online courses, textbooks, instruction, or any resource that supports access to information (Atkins, Brown, & Hammond, 2007). Khan Academy provided video-based teaching and sample problems with an audiovisual (Kelly & Anderson, 2017). When learners correctly solved problems, students were awarded badges and points.

Kelly and Rutherford (2017) conducted a posttest only, control group quasi-experimental design study to determine if Khan Academy impacted mathematical achievement. Participants in the study were Grade 7 students (n = 114) from a charter school in North Carolina. The school was located in a suburban, area and students achieved above-average scores on the mathematics end-of-grade assessment. The sample participants included gifted/talented and students with special needs who were enrolled in a mathematics elective course. The course was assigned to students to develop mathematical skills and to supplement student learning. One group contained 75 students (i.e., experimental group), and the second group contained 39 students (i.e., control group). Participants in the control group were enrolled in an enrichment classroom and received instruction based on the decision of the teacher. Participants in the treatment group completed mathematical lessons with Khan Academy. During the four-week study, treatment group participants used the program for 30 minutes a day. The treatment group teacher did not assign topics for learners to complete on the program, so the participants selected the Grade 7 mathematical topics that they wanted to complete each day.

To measure the control and experimental groups' achievement, a common posttest assessment was administered to all students. Participants were assessed with 21 questions from a Grade 6 North Carolina mathematics end-of-grade assessment. Researchers, Kelly and Rutherford (2017), used an independent samples *t*-test to determine the effect of Khan Academy on student achievement. After the intervention, the mean of the control group was 72.22, and the treatment group was 73.75. From the analysis of the mean scores, there was not a statistically significant difference between the scores ($p = .596$). When analyzing the posttest scores, there was not a statistically significant difference between the two groups, $t(60) = -1.009$, $p = .842$.

Next, correlational relationships were analyzed between the posttest scores of the treatment groups and factors with Khan Academy (i.e., time, topics that were covered, and points that were earned; Kelly & Anderson, 2017). First, time on Khan Academy was not associated with test scores, $r(37) = .12$, $p = .422$. Next, a positive association was identified between time using Khan Academy and the number of topics that were mastered, [$r(37) = .76$, $p = .001$]. A positive relationship was also identified between test scores, number of topics that were mastered [$r(37) = .51$, $p = .001$], and points that were attained [($r(37) = .41$, $p = .009$].

The study contained implications, limitations, and suggestions for future research. Based these data, the researchers implied that the additional mathematical enrichment did not improve student achievement. Another implication was the different elements (i.e., minutes spent, points attained, and topics mastered) within Khan Academy could impact student achievement. The researchers found that participants' prior knowledge or achievement could impact the program's elements and achievement scores (Kelly & Anderson, 2017).

A limitation was the intervention enrichment classroom lacked structure. Teachers in the intervention classroom did not assign Khan Academy lessons to participants, and learners completed lessons deemed important to the user. Other limitations were the scope and generalizability of the study. Kelly and Anderson (2017) identified future suggestions to improve the study. One recommended suggestion was to include diverse demographics in the study. Another suggestion was to limit internal validity. The final suggestion for future research was to include relevant covariates (i.e., race, gender, and ethnicity) to make the study generalizable to other populations.

Table 4, below, summarizes quantitative, mixed methods, and quasi-experimental studies that were reviewed to identify how computer-assisted instruction was utilized in educational classrooms. The participants in the studies were Grade 6 through Grade 8 students from North Carolina, Kansas, New Jersey, Virginia, and Maine. Researchers, Roschelle et al. (2016) and Kelly and Rutherford (2017), conducted studies with Grade 7 students with ASSISTments and Khan Academy. Chappell et al. (2015) analyzed Focus Edu Vision software on mathematical achievement, and Tienken and Maher (2008) used a specific computer-assisted instructional program. Participants from Chappell et al. (2015) and Roschelle et al. (2016) studies increased mathematical achievement. In contrast, participants in Tienken and Maher's (2008) and Kelly and Rutherford's (2017) studies did not improve student achievement.

Table 4

Concept Analysis Chart for Computer-Assisted Instruction

Study	Purpose	Participants	Design/Analysis	Outcomes
Tienken & Maher (2008)	To investigate the effect of computer-assisted instruction on student achievement.	284 Grade 8 students and four randomly assigned teachers from Central New Jersey	Quantitative, quasi-experimental study ANOVA	Students in the treatment group scored significantly lower than the control group students. Students in the control group outperformed their peers in the treatment group on the New Jersey Grade Eight Proficiency Assessment mathematics section. Asian students in the control group outperformed all other students in treatment and control groups.
Chappell et al. (2015)	To determine the impact of an online tutorial program on students receiving mathematics intervention.	119 students from two middle schools. School 1: southern Virginia (69 Grade 6 students) School 2: Central Kansas (70 Grades 7 & 8 students)	Mixed methods ANCOVA	Treatment group increased in achievement. Posttest scores of the two groups did not display a significant difference. Mean score of control group

Study	Purpose	Participants	Design/Analysis	Outcomes
				participants decreased after the posttest. Both groups had statistically significant within-group increases from pretest to posttest.
Roschelle et al. (2016)	To determine if online mathematics homework increased student achievement.	2,850 Grade 7 students and teachers from Maine	Quantitative delayed treatment design Terra Nova hierarchical linear model	Low-performing students performed significantly better than high-achieving students
Kelly & Rutherford (2017)	To determine if Khan Academy impacted mathematics achievement.	Grade 7 students (n = 114) from a charter school in North Carolina	Posttest only control group quasi-experimental design	Mathematics enrichment did not improve student achievement. Khan Academy did not improve student achievement.

Computer-Enriched Instruction

Computer games created discovery opportunities for conditions that resembled real-life practices and promoted critical thinking and problem-solving skills to help students become successful (Mahmoudi et al., 2015). When games were implemented, student motivation and mathematical knowledge were impacted. Johnson (2017), Morales (2016), Kiili et al. (2015), and Katmada, Mavridis, and Tsiatsos (2014) conducted studies with educational softwares to demonstrate how student motivation and mathematical knowledge were impacted by educational software. Johnson (2017), Morales (2016), Kiili et al. (2015), and Katmada et al. (2014) found that educational software significantly impacted motivation, mathematical achievement, or both motivation and achievement.

Johnson (2017) used a case study to determine how a basic learning program (i.e., Game Maker) could improve student knowledge by programming. The aim of the study was to identify what students learned by creating a game about the life cycle. Participants in the study were 22 Grade 8 students (i.e., 12 males and 10 females) from a school in southeast England. Purposive sampling was used to select participants based on learning ability. The study was conducted over an eight-week time frame, for 16 hours each week. During the study, qualitative data were collected using transcripts, voice recordings, interviews, interview schedules, and a coding system (Johnson, 2017). The results from the study revealed that students were able to recall and visualize previously taught content. Results also indicated that computational thinking was developed, students were motivated to learn about designing games, student engagement increased, and student discipline issues decreased. The limitations to the study included the small sample size, the above-average ability level students, and the lack of benefit for programming knowledge. Johnson (2017) suggested that future research could contain studies exploring what students learned from a collaborative game design, and the impact of Game Maker on different subject areas. Johnson also suggested to determine if gender or the type of game impacted student knowledge.

Another study conducted by Morales (2016) used computer-enriched instruction to determine the effect on student achievement. Morales directed research on a sixth-grade class in a parochial school in the midwestern United States. The purpose of the quantitative study was to analyze the effects of integrating educational software (i.e., Front Row) to differentiate mathematics instruction. The research was conducted over a five-week period for fifteen 45-minute sessions of students using the software or small group instruction with Chromebooks. The researcher collected data from 10 students (i.e., five females and five males), and one teacher. Data were collected from reflection questions, teacher observations, computer reports from the Front Row software, and student questionnaires. First, the researcher administered a 12-question survey to determine the students' comfort with technology. After the survey, students completed the diagnostic test to determine student knowledge on foundational (i.e., K-5 standards) and advanced (i.e., 6-8 standards) concepts. After completing the diagnostic test, students were assigned lessons based on scores from the assessment. The Front Row software assigned students mathematical concepts, and students were not allowed to progress toward another standard until a certain number of problems were answered correctly.

From the study, Morales (2016) determined that students were engaged and motivated to complete lessons. After every lesson, students completed a questionnaire and were held accountable for learning the content. Each week, the researcher gathered data from Front Row to create differentiated lessons for struggling students and modified instructional content for one student to complete with an iPad. From the student surveys, data indicated that low-achieving students enjoyed learning mathematics when Front Row was used in the classroom, but no statistically significant effect was identified for middle- and high-achieving students. Student motivation also increased using Front Row because students wanted to earn coins on the program and purchase items. The results from the study indicated that learning gaps decreased because the program began each student in a certain area and that students increased knowledge of mathematical content.

Kiili et al. (2015) analyzed computer-enriched instruction with Semideus and Wuzzit Trouble video games. The video games were used to combine learning and assessment in mathematical instruction. The purpose of the study was to determine if computer games were effective when combined with student learning and assessment. The participants consisted of two Finnish (n = 30) and two U.S. (n = 36) Grade 6 classes. The average age of Finnish students was 12.1 years, and the average age of U.S. students was 11.43 years. The study used a pretest/posttest quasi-experimental design, with a treatment group and a control group, with two software programs. At the beginning of the study, students completed a questionnaire and a pretest. The pretest and posttest were the Semideus game. The study was conducted over two months, and students participated in the study for 40 minutes per week. Each student used an iPad to play the Wuzzit Trouble learning game. At the conclusion of the study, students completed a posttest. The results of the study indicated that a game could be used to test mathematical skills, student conceptual knowledge increased, and students' understanding of rational numbers increased. The limitations to this study were the small sample size, the knowledge level of the treatment group was lower than the control group, and there were scheduling conflicts with schools. Kiili et al. suggested that future research could be conducted with larger sample sizes and by utilizing formative assessments with the software.

Another study conducted by Katmada et al. (2014) used a pilot study to determine if a computer-enriched video game (i.e., Volcanic Riddles) supported student learning in mathematics. Volcanic Riddles was an online two-dimensional game that was created to support teaching mathematics (Katmada et al., 2014). The video game contained motivational features, goals, instructional content, challenges, opposition elements, interaction, and immediate feedback. A pilot study was conducted with 12 Grade 6 students (i.e., eight females and four male) from a private school. At the beginning of the study, students completed an 18-item questionnaire. During the study, the researchers observed students and recorded notes. The results from the first evaluation could not be analyzed due to a small sample size, so the researchers conducted a second experiment. The second study was 14 weeks with 37 randomly selected students (i.e., 23 males and 14 females) who were 12 to 14 years of age. At the start of the study, students completed a paper-based questionnaire with 22 questions. The questionnaire was used to determine students' perceptions of the game. Participants played the game daily at home, and a debriefing session was held every two weeks in the computer lab.

At the end of the study, students completed another questionnaire. The data from the Likert-type questions were analyzed with descriptive statistics, and open-ended questions were grouped according to shared topics. Common themes were identified from the open-ended questions, which included the game significantly affected students' understanding of the content, lessons were engaging, and flexible learning was promoted. Participants felt that the game was easy to understand ($M = 4.67$, $SD = 0.778$, $N = 12$) and that the game could improve achievement ($M = 4.58$, $SD = 0.669$, $N = 12$). The results from the study also indicated that students developed an improved understanding of arithmetic and geometrical concepts with the game-based software. Some limitations for the study included the age of the participants and a limited number of challenges on the game. Future research suggestions by Katmada et al. (2014) were to add new features to the game, provide more hints, provide more feedback to students, and enhance student engagement.

Table 5, below, summarizes qualitative, quasi-experimental, and quantitative studies on computer-enriched instruction that were reviewed. Participants in Grades 6 through 8, from different parts of the world, were included in the studies. The studies involved computer-enriched instruction that was conducted in regular education classrooms, in high-achieving classrooms, and as an intervention program. Johnson (2017), Katmada et al. (2014), Kiili et al. (2015), and Morales (2016) analyzed the effect of different computer programs on student achievement. From the studies, students' mathematical achievement increased with the computer-based instruction, learning gaps decreased, flexible learning was promoted, and motivation increased. In contrast, Camilleri and Camilleri (2017) analyzed students' perceptions of using games to learn educational content. From this study, participants' digital learning, critical thinking, interpersonal and social skills improved.

Table 5

Concept Analysis Chart for Computer-Enriched Instruction

Study	Purpose	Participants	Design/Analysis	Outcomes
Katmada et al. (2014)	To determine if a computer game supported student learning in mathematics.	1st study: 12 Grade 6 students (i.e., eight females and four male) from a private school 2nd study: 37 randomly selected students (i.e., 23 males and 14 females) 12 to 14 years of age	Qualitative Pilot study Paper-based questionnaire	Game significantly affected students' understanding of the content and promoted flexible learning. Students learned with the game-based software.
Kiili et al. (2015)	To determine if computer games were effective when combined with student learning and assessment.	Two Finnish and two U.S. sixth-grade classes 66 students, 30 Finnish and 36 U.S. students	Pretest/posttest quasi-experimental	A game could be used to test mathematical skills. Students' conceptual knowledge increased, and students' understanding of rational numbers increased.
Morales (2016)	To analyze the effects of integrating educational software to differentiate mathematics instruction.	Sixth-grade class in a parochial school in midwestern United States	Quantitative study Software data Questionnaires	Student engagement and motivation increased. Learning gaps decreased.

Study	Purpose	Participants	Design/Analysis	Outcomes
Camilleri & Camilleri (2017)	To determine students' perceptions of using digital games in classrooms.	41 participants from 10 schools in northern harbor Malta	Qualitative study Purposive sampling	Digital skills and learning improved. Interpersonal and social skills improved. Critical thinking and problem-solving skills improved. Student engagement increased. Promoted collaboration among peers.
Johnson (2017)	To determine how a basic learning program improved students' knowledge of programming.	22 Grade 8 students (i.e., 12 males and 10 females) from a school in South East England	Qualitative Case study using transcripts, voice recordings, interviews, interview schedules, and a coding system	Recall and visualize previously taught content. Indicated computational thinking was developed. Students were motivated to learn about designing games. Student engagement increased and student discipline decreased.

Computer-Simulated Instruction

Küçükalkan et al. (2019) identified computer-simulated instruction as teaching through real-life simulated events. When computer-simulated instruction was used, the activities allowed students to transfer knowledge that was obtained from the computer-generated activities to actual events (Nwineh & Okwelle, 2018). As stated by Cai et al. (2017), computer-simulated instruction was used to display events that were difficult to examine. The simulated instruction using a computer program modeled real-life experiences to improve problem-solving abilities and increased student learning (Slavin, 2006). Mechling and O'Brien (2010) stated that computer-simulated and video-based instruction were used to present real-world mathematical problems. Video-based instruction reduced extraneous stimuli that could be distracting in the classrooms (Bellini & Akullian, 2007). Cannella-Malone et al. (2011) and Gardner and Wolfe (2013) identified two types of video-based instruction, which included video modeling and video prompting. When video modeling occurred, learners viewed someone performing the entire skill or task, then the students repeated the task (Banda, Dogoe, & Matuszny, 2011). When video prompting occurred, the skill or task was broken down in steps, and the student completed one phase before progressing to another level (Banda et al., 2011). Wu, Lee, Chang, and Liang (2013) identified another type of simulated instruction that used augmented reality technology, an extension of virtual reality. This type of computer-simulated instruction used real-world scenes, enhanced by virtual data, which provided a natural way to teach and interact with the components of the program. Augmented reality was used when the phenomenon was too large or too small to replicate or when real experiments were too dangerous to simulate (Cai, Chiang, & Wang, 2013; Cai, Wang, &

Chiang, 2014; Chang, Wu, & Hsu, 2013). Saunders, Spooner, and Ley Davis (2018) and Pritami and Muhimmah (2018) conducted studies with computer-simulated instruction to determine the impact on student achievement. From the studies, student motivation and mathematical achievement increased from playing the simulated activities.

Saunders et al. (2018) conducted a study with computer-simulated instruction (i.e., video-based instruction). The purpose of the study was to identify the perceptions and effects of video- and computer-simulated instruction with students with moderate learning disabilities. The study involved three urban middle schools from the southwest United States. Participants from the schools included 1,128 Grade 6 through Grade 8 students. A specific criteria and convenience sampling were used to select Grade 7 and Grade 8 students. The criteria to identify participants contained six parts: 1) diagnosed as having moderate intellectual disability, 2) could independently count 1 to 10, 3) count with one-to-one correspondence to 10, 4) made sets of numbers up to 10, 5) maintain attention to a video for 5 minutes, and 6) consent forms contained were signed. From the identified criteria, three participants were selected for the study. Pseudonyms for students were Brad, Heather, and Benito. The participants were administered baseline instruction to determine their mathematical abilities. Brad contained the most inconsistency in baseline quantities, Heather had the most stable baseline, and Benito's baseline measures remained low and constant.

The study was conducted in a conference room every morning from 9:30 a.m. to 11:00 a.m. In the conference room, two research assistants delivered the intervention. The experimenters were doctoral-level graduates with experience teaching students with disabilities. Researchers used a multiple probe across participants design with three phases (i.e., addition, subtraction, and mixed addition and subtraction). During the intervention, participants viewed two training videos and solved four computer-simulated mathematical problems. The mathematics questions required participants to remember the strategies to solve addition and subtraction problems. During the video-simulated lessons, a visual and narration of the problem was provided, and the problem was broken down into six steps. With each step, explicit commentary and practice problems were provided to participants. When participants correctly answered a question, verbal praise was directed toward participants. When participants did not solve a problem correctly, the experimenter replayed the video, and different prompts were given to assist participants to solve the problems. After completing the videos, a self-monitoring checklist was provided to participants to monitor progress (Saunders et al., 2018).

The results from the participants' baseline and intervention data were determined by phase mastery. In Phase 1, addition, Brad displayed mastery after 13 sessions, Heather demonstrated mastery after 20 sessions, and Benito exhibited mastery after 25 sessions. In Phase 2, subtraction, Brad displayed mastery after seven sessions, Heather showed mastery after six sessions, and Benito did not master the phase. In Phase 3, mixed addition and subtraction, Brad and Heather demonstrated mastery after four sessions, and Benito did not reach the phase. At the completion of the video-simulated problems, Brad achieved a 95, and Heather made a 92. Mastery data with the simulated lessons, steady prompting, and error correction steps indicated that students' mathematical skills improved (Saunders et al., 2018).

The study contained implications, limitations, and suggestions for future research. Saunders et al. (2018) identified four implications from the study. First, Mechling and

O'Brien (2010) identified video creation of problems was uncomplicated and achievable. Second, laptops were used widely and could be used to create or edit videos. Another implication was the use of simulated instruction could decrease the restrictions with public education. The final implication was video instruction could be used with real-world situations. The study also contained four limitations. First, the location of the study was a restraint. Some school districts taught students with moderate learning disabilities in inclusion settings, and other schools used self-contained environments. Another limitation was the type of problems in Phase 1 and Phase 2. The phases only contained one type of mathematical problem and caused internal validity. The third limitation was one participant did not complete the study. The final limitation was the results could not be generalized to other populations.

Saunders et al. (2018) identified recommendations for future research for the study. One suggestion to improve the study was to add more participants. The use of three participants decreased the amount of comparable data because one participant did not complete the study. Another suggestion for future studies could be to use more experimenters. The use of more investigators could be used to identify the effects of the intervention with students in regular classrooms. The third suggestion identified by Saunders et al. was to include different types of mathematical problems to decrease internal validity. The final suggestion, to improve the study, was to include different demographics to allow the results to be generalized to other populations.

Pritami and Muhimmah (2018) conducted a qualitative study to identify the effects of a mathematical computer-simulated instruction. The researchers used a digital learning game with augmented reality with students from Yogyakarta, Indonesia. The augmented reality game (i.e., DorDor) contained elements, such as action, first-person shooter, adventure, trivia, and augmented reality. The purpose of the simulated activity was to generate student engagement and to improve counting and motor skills. Participants from the study included 60 randomly selected students from Grade 3 through Grade 6. The researcher unsystematically selected 15 students from each grade level to use the simulated game with four smartphones. Participants could play the simulated game for 10 minutes on the device. During gameplay, researchers observed participants' actions while playing the game. From observations, researchers identified how participants were engaged during gameplay, wanted more time to play the game, and were motivated to achieve high scores on the game.

Results from the study provided information on advantages and limitations of using the application. Pritami and Muhimmah (2018) identified that the simulated activity helped students learn mathematics, have fun learning, increased student engagement, and promoted collaboration to solve problems. Once the 10 minutes were completed, participants wanted to play the games again. When some participants struggled to solve difficult mathematical problems, peers helped solve the problem. Although the application impacted student learning, researchers identified limitations of the simulated activity. The limitations were the use of the internet to access the application, the location to play the game, lag time of the game, and the amount of power to run the game. Only participants at one school could access the game. Because the simulated game was internet-based, gameplay paused during student use and decreased the power of the smartphone. With the identified limitations of the study, Pritami and Muhimmah identified suggestions for future research. To be more efficient, the lag time of the application could be resolved, and problems with the internet application could be decreased.

Table 6, below, summarizes studies using a multiple probe across participants design and a qualitative study to identify the effect of computer-simulated instruction on student learning. Participants in the studies were Grade 3 through Grade 8 students from Indonesia, Netherlands, Malaysia, India, Belgium, and the United States. Results from Saunders et al. (2018) identified that mathematics achievement increased with the use of computer-simulated instruction. Participants used video-based instruction to apply addition and subtraction steps that were learned from the video. In another study conducted by Pritami and Muhimmah (2018), augmented reality was used to improve counting skills. In this study, participants were motivated to learn with the simulated, game and student engagement increased.

Table 6

Concept Analysis Chart for Computer-Simulated Instruction

Study	Purpose	Participants	Design/Analysis	Outcomes
Pritami & Muhimmah (2018)	To generate student engagement and to improve counting and motor skills.	60 Grade 3 through Grade 6 students from Indonesia	Qualitative Observations	Student engagement increased. Students learned mathematics.
Saunders et al. (2018)	To identify the perceptions and effects of video- and computer-simulated instruction on student achievement.	Three students from three urban middle schools from southwest United States	Multiple probe across participants design	Mathematical skills improved with simulated lessons.

Computer-Managed/Mediated Instruction

Bhalla (2013) identified computer-managed instruction as a teaching strategy that used computers to provide learning resources and objectives, track and gather data, assess student knowledge, and recommend customized learning plans. Computer-mediated instruction provided students the flexibility to complete topics in a desired pace and order (Drowning & Gifford, 1996). Computer-managed instruction was a more specific term than computer-mediated instruction (Hunyadi, Pah, & Chiribuca, 2009). The word, “managed”, indicates technology did not contribute directly to teaching and learning methods but served as a system for managing the learning process. The word, “mediated”, is a broad term to identify technology used as learning resources or as a tutor for a subject. The software identifies students’ mathematical deficiencies to skip mastered concepts of the curriculum, provides immediate feedback, and creates an individualized learning plan (Twigg, 1999). Bickerstaff, Fay, and Trimble (2016) explained that computer-mediated instruction provided students with an infinite bank of problems and worked examples. Computer-mediated instruction could be combined with teacher-led or lecture-based instruction. Barnes, Fay, Pheatt, and Trimble (2016) identified that the instructional software provided free lectured courses to instructors to provide one-on-one support to students.

Day and Payne (1987) identified computer-managed instruction as a teaching strategy that allowed teachers to arrange student data, make instructional decisions, evaluate student performances, identify instructional resources, track student progress, and provide organizational support to teachers. Leiblum (1982) stated that computer-managed instruction contained 12 elements, which include a) different objectives, b) stockpile of learning resources and collection of information recovery, c) learning material, d) diverse items, e) element production, f) test creation, g) evaluation, h) recording, i) measurement, j) assignment, k) analysis, and l) planning. Hedges (1981) and Park and Lee (2003) combined the 12 elements into four functions, which include analyzing, recommending, gathering data, and recording data.

Wee, Abrizah, and Por (2012) conducted a case study to explore the effect of an online computer-managed instructional forum. Participants were selected from 17 public universities from the Ministry of Higher Education in Malaysia. From the population, the sample included 64 students and five educators. Student participants were required to complete a group project and discuss issues in an online discussion forum. The online computer-managed instructional forum updated the participants' performance. When participants posted a message, the learner contribution records were updated instantly, and posts could be changed. The forum software enabled participants to post a new topic, analyze other posts, and respond to posts. To determine the impact of the computer-managed instructional forum software, participants completed two online courses (i.e., Information Retrieval and Knowledge Management). After the completion of the courses, which took nine weeks, participants completed a 20-question electronic survey. The questions from the survey were created with a three-point response scale, including *Agree, Undecided*, and *Disagree*. Researchers used the Software Usability Measurement Inventory to assess the quality of the computer-managed instructional forum (Kirakowski & Corbett, 1993). The survey was emailed to participants, and two follow-up emails were sent to participants who did not complete the questionnaire within one week.

After the study, data from the participants' posts (i.e., subject, time, date, and category) were collected and analyzed. From the 64 participants, 49 questionnaires were returned, which yielded a 76.6% response rate. Results from the questionnaires indicated that participants posted with minimal difficulty (i.e., 50% agreed) with the software. The computer-managed instructional software also produced learning opportunities that were helpful, effective, and efficient. The evaluation of the results from the questionnaire suggested that the forum software was "better than that of a human instructor" (Wee et al., 2012, p. 230).

Wee et al. (2012) identified implication, limitations, and suggestions for future research for the study. The instructional tool could offer supplementary grading to provide immediate feedback to students. One limitation was the use of the forum software on two different courses. Future researchers could expand the review of the research environment and the scope of the users to other academic subjects and could explore an alternate procedure to categorize posts.

Fay (2017) conducted an exploratory qualitative study to investigate the effect of computer-mediated instruction at high schools and community colleges in Tennessee. The purpose of the computer-mediated instruction was to decrease the amount of time to improve students' mathematical development in remedial courses (Center for Community College Student Engagement, 2016). The computer-mediated instruction selected for the study were Learning Support Mathematics and Seamless Alignment Integrated Learning Support. The Learning Support Mathematics was a course used at the Tennessee community colleges to determine if students were ready to enter college. The Seamless

Alignment Integrated Learning Support course was offered in Tennessee high schools for Grade 12 students who were not college ready at the end of the 11th grade (Fay, 2017).

The computer-mediated instruction consisted of five mathematical modules with a "pretest, problem sets, quizzes, and a posttest" (Fay, 2017, p. 11). The content that was covered in the learning modules were real number sense and operations, functions with algebraic expressions, analyzing graphs, solving equations, modeling, and critical thinking. Once students mastered the content from the module, the students moved to the next module. When students completed the five units, students were identified as mathematically prepared for college admission for any college or university in Tennessee.

Participants in the study were enrolled at three community colleges and four high schools in Tennessee. Community colleges were selected to participate in the study based on the willingness and ability to have a one-day site visit for researchers. High schools were selected based on partnerships with colleges that the researchers visited. The researchers conducted semi-structured interviews with college and high school administrators, mathematics department deans, software instructors and coordinators, mathematics coordinators, and student focus groups. The interview questions were designed to provide data on how the courses were implemented and the students' experience with the computer-mediated instructional class. Additionally, the researcher observed three classes at each high school (Fay, 2017).

Results from the qualitative data revealed that the computer-mediated instruction utilized in high schools accelerated mathematical learning. Results from the interviews identified two factors that impacted student achievement on the computer-mediated instruction. The first factor, operational, included attendance policies, frequency of class, course completion requirements, and the coordinator. The second factor, culture, included expectations of independent work, value of the course, student motivation, and relationships. The high schools and community colleges contained contrasting cultural and operational practices. High schools developed low expectations for student independence, and the structure and cultural procedures were constructed around student behaviors. High schools also created stronger attendance policies, encouraged students to complete the five units, and used social systems to create responsibility of student progress. The community colleges developed high expectations for students' self-sufficiency and self-regulation. Colleges also developed ineffective operational and educational procedures to manage student behavior. The attendance policies of community colleges were not rigorous, students were not required to complete all modules, and efforts were not made to motivate and monitor student progress.

Fay (2017) identified implications, limitations, and suggestions for future research. One implication of the study was the computer-mediated instruction could develop students' self-monitoring skills. Another implication was the instructors could promote autonomy in the classrooms to improve self-motivation. The final implication was the Seamless Alignment and Integrated Learning Support courses could prepare all students for college-level courses. A limitation of the study was student performance on college-level mathematics was not provided to the researcher after completing the modules. A suggestion for future research studies was to have instructors develop independence of learning to promote and support the development of academic motivation.

Table 7, below, summarizes studies using an exploratory qualitative design and a case study to identify the effect of computer-managed and computer-mediated instruction on student learning. Participants in the studies were elementary, middle, high school, and college students from Tennessee and Malaysia. Results from Wee et al. (2012) and Fay (2017) indicated that computer-managed and computer-mediated instruction produced student learning opportunities.

Table 7

Concept Analysis Chart for Computer-Managed Instruction and Computer-Mediated Instruction

Study	Purpose	Participants	Design/Analysis	Outcomes
Wee et al. (2012)	To identify if computer-managed instructional forums impacted students' knowledge.	64 college students and five educators from Malaysia	Case Study Survey Questionnaire	Computer-managed instruction produced learning opportunities and was considered effective and efficient.
Fay (2017)	To identify if computer-mediated instructional modules impacted mathematical achievement.	Three high schools and four community colleges from Tennessee	Exploratory Qualitative Interviews Case study Observations	High school computer-mediated instruction increased students' mathematical knowledge.

i-Ready and Student Achievement

In 2010, Curriculum Associates (2015a), an educational company, developed "valid and reliable K-12 diagnostic, individualized K-8 student online instruction and teacher led instruction in a product" (p. 2). According to Curriculum Associates (2015a), "each instructional module in i-Ready instruction is structured with a tutorial that provides modeled and guided instruction, a practice activity that supports and reinforce student learning, and a quiz for independent practice and assessment" (p. 6). The online instruction contains resources from kindergarten to eighth-grade mathematics to provide students with differentiated content. The instructional content includes standardized activities, interactive whiteboard activities, assessments, and learning videos (Curriculum Associates, 2016). The interactive tutorials provide videos, aligns to the Common Core math standards, and are visual representations of the in-class mathematical instruction. i-Ready (2018) stated that the supportive tutorials provide immediate feedback and explanations based on a student's response to a problem.

Hall (2019) conducted a mixed methods pretest-posttest design study on middle school students. The purpose of the study was to measure the change in mathematical performance of students who watched i-Ready tutorial videos. The videos were used to help students improve overall mathematics achievement. The study also examined the participants' self-efficacy and apprehension with mathematical tutorials. The sample participants were selected from a suburban middle school in middle Tennessee, with a population of 571 students. The demographics of the school included 91% Caucasians, 5% Hispanics, and 4% African Americans. The school was classified as Title I, and 36.7% of the students received free or reduced lunch. Sample participants in Grade 7 and

8 were separated into treatment (n = 13) and control (n = 50) groups. Control group participants were selected randomly, and treatment group participants were selected based on STAR Math scores. Treatment group participants were students who received Tier II and III response to intervention services. Participants in the study were divided into four cohorts (i.e., fall, spring, both, and control). Participants in the fall cohort received and completed the i-Ready tutorials in the fall semester. The spring cohort received and completed i-Ready intervention in the spring semester. Participants in both cohorts received the intervention in the fall and spring semesters. Participants in the control cohort did not receive the intervention and did not participate in the self-efficacy and anxiety survey. On the STAR Math assessment, participants answered 34 timed questions. Once a question was answered, the degree of difficulty increased with correct answers and decreased with incorrect answers.

The quantitative data sources were pretest, posttest, and mathematical self-efficacy and survey. Before the pretest and at the conclusion of the study, the mathematical self-efficacy and anxiety survey was administered. The survey contained 29 open-ended statements (i.e., 14 self-efficacy and 15 anxiety) and measured with a five-point Likert-type scale (i.e., 1 = *never,* 3 = *sometimes,* and 5 = *always*). The pretest and posttest were administered with the i-Ready intervention program. The assessment contained four to six questions to evaluate a specific Common Core standard. Hall (2019) collected qualitative data from a focus group of 15 randomly selected treatment and control group participants. The focus group identified student perceptions of how effective the mathematics tutorials supported general classroom lessons.

To analyze the quantitative data, a mixed model ANOVA, paired samples *t*-test, and a one-way ANOVA were conducted. The mixed model ANOVA was used to analyze the STAR Math assessments of the fall, spring, and both groups. The STAR Math screener throughout the school year was statistically significant, $F(3, 309) = 6.62$, $p < .0001$, and the four different treatment cohorts differed significantly, $F(3, 103) = 4.76$, $p < .01$. On the STAR Math scale score, the control group ($M = 30.78$) and the fall cohort treatment group ($M = 20.56$) achieved the highest growth at the completion of the study. Participants who received the treatment during both semesters achieved significant gains with their scaled scores ($M = 30.18$), compared to an 8.67 mean gain in the fall cohort and a 17.77 mean gain for the spring cohort. A paired-samples *t*-test was used to analyze the pretests and posttests. A marginal significant difference was achieved from the seventh-grade pretest and posttest scores ($p = .058$). The eighth-grade pretest and posttest results exhibited statistically significant effects ($p = .001$). The mathematical self-efficacy and anxiety survey was analyzed with a mixed-model ANOVA. The interaction between the overall survey and the different cohorts was not significant, $F(2, 59) = 2.00$. The differences among the cohorts, $F(2, 59) = 1.67$, and the overall survey, $F(1, 59) = 0.00$, were not statistically significant. A mixed-model ANOVA was used to compare the overall seventh-grade survey responses among each of the cohorts. The interaction between the two variables was statistically significant, $F(2, 28) = 4.07$, $p < .05$. A mixed-model ANOVA was conducted to compare the overall survey data for the eighth-grade students in each cohort. The overall eighth-grade mathematical self-efficacy between the different cohorts was not significantly different, $F(2, 28) = 0.20$. Overall, the spring cohort (i.e., Grades 7 and 8), when separated by grade, showed an increase in mathematical self-efficacy. From the focus group, participants perceived that peer interactions and the role of the teachers led to students' reassurance in the general mathematics classroom (Hall, 2019).

Hall (2019) identified two implications and three recommendations for the study. One identified implication was the results of the study could impact the use of educational software in mathematics' classrooms. With the results, a foundation could be created to analyze computer-based instruction. Another implication was the intervention impacted students' mathematical self-efficacy and anxiety. With more studies on identifying the effect of computer-based instruction on mathematical self-efficacy and anxiety, more software or programs could be created to promote learning in the educational setting. The researcher suggested that continued research on how the duration of the intervention could impact mathematical self-efficacy and anxiety levels. Continued research could also be conducted to determine if the intervention closed mathematical achievement gaps. The final recommendation was to provide professional development to teachers before implementing the intervention. When teachers received effective training, "students will maximize the resources from the instructional tool" (Hall, 2019, p. 124).

Effects of Computer-Based Instruction

Computer-based instruction is an instructional approach that incorporated computer software programs with supplementary teaching resources (Ryan, 2017). The U.S. Department of Education (2013) identifies computer-based instruction as an effective strategy to provide instruction for low-achieving students. Computer-based instruction enhances student learning with differentiated instruction, provides immediate feedback on problems, and allows low-achieving students to work at a desired pace (Ryan, 2017).

Küçükalkan et al. (2019) conducted a meta-analysis study to combine, analyze, and evaluate different computer-based instruction. The purpose of the study was to analyze the overall effect size of computer-based instruction on students with mild learning disabilities. The study used a population of 2,290 participants from different countries. The analyzed studies came from the United States (n = 15), Belgium (n = 2), India (n = 1), Malaysia (n = 3), and the Netherlands (n = 10). The study consisted of an experimental group (n = 1,364) and a control group (n = 926). Researchers, Küçükalkan et al. (2019), used the Hedge's g to measure the effect size of computer-based instruction on student achievement. Hedges (1983) identified the different effect size ranges were: significant ($g < .15$), small ($.14 < g < .40$), medium ($.39 < g < .75$), high ($.74 < g < 1.10$), very high ($1.09 < g < 1.45$), and excellent ($g > 1.44$).

Researchers used a comprehensive meta-analysis software to analyze the effect size of computer-based experimental studies by combining data from similar studies (Cohen, Manion, & Marrison, 2011). The comprehensive software was used to analyze 33 applications, 11 research studies, and four categories of computer-based instruction. The comprehensive meta-analysis software indicated that the computer-based instruction systems produced a medium effect ($g = .606$) with the examined experimental groups. When the computer-based instruction groups were implemented in educational environments, the effect sizes were small (i.e., computer-simulated instruction) to medium (i.e., computer-assisted instruction, computer-enriched instruction, and computer-managed instruction). The result of using computer-assisted instruction (g =

.511), computer-enriched instruction (*g* = .442), and computer-managed instruction (*g* = .674) in educational settings generated a medium effect on student achievement, and computer-simulated instruction (*g* = .378) produced a small effect on student achievement. The effect size of using computer-based instruction in different countries ranged from medium to large. The outcomes for Belgium (*g* = .929), India (*g* = 1.1012), and Malaysia (*g* = .887) were large, but U.S. (*g* = .467) and the Netherlands (*g* = .678) had medium effect sizes on student achievement. From the results of the analyzed studies, Küçükalkan et al. (2019) determined that computer-managed instruction was the most effective method of computer-based instruction to improve student achievement.

Küçükalkan et al. (2019) provided limitations and recommendations for future research for the meta-analysis. The study contained four limitations. First, the research contained a small number of studies (*n* = 11) that represented the experimental groups. This limitation affected the generalizability of the study. Another limitation to the research was the number of countries (*n* = 5) that were represented in the study. This sample size limited the amount of data that were generated for the study. The third limitation was the reduced amount of research with computer-based instruction to teach mathematics. The final limitation was the lack of research data regarding gender. With these limitations, Küçükalkan et al. identified some recommendations for future studies. Possible studies could include computer-based instruction to enhance the generalizability of the results. In addition, future research could use more computer programs or applications to teach students with learning disabilities.

Gilmore (2018) used a correlational study with a pretest-posttest control group design to determine the impact of computer-based instruction on mathematical achievement. The study used convenience sampling to select students and teachers from two middle schools in southeastern Georgia. The two schools (i.e., School A and School B) had a population of approximately 705 to 725 students. School A had 50 teachers, and School B had 48 teachers. Both schools were Title I schools, with 66% of School A students receiving free or reduced lunch and 70% of School B students receiving free or reduced lunch. From the population, 83 students were selected conveniently for the study. The selected participants (i.e., 46 males and 37 females) were at least two grade levels behind on the STAR Math pre-assessment. From the sample, 25% were Caucasian, and 75% were African American. The participants were separated evenly into the control and experimental groups. The control group participants (n = 39) received traditional mathematical instruction for 50 minutes each day from a certified teacher. The experimental group (n = 44) used Math 180, an intervention program for mathematical concepts and skills, for 50 minutes a day. In this group, the teacher supervised and facilitated student learning on tasks. At the end of the 18-week study, participants completed the STAR Math posttest. The researcher also collected data from the software's internal monitoring database on the amount of time that treatment group participants used the software.

Participants in the experimental group (M = 682.527) scored higher on the STAR Math posttest than the control group participants (M = 674.047). Although the experimental group scored higher on the posttest, there was not a statistically significant difference between the scores [$F(1, 80) = .39$, $p < .54$, partial $\eta = .005$]. Gilmore (2018) also analyzed the effect of gender and race with and without the intervention. Male participants scored higher on the posttest (M = 692.526) than female participants (M =

671.784). A statistically significant difference was not identified between males and females on the STAR Math posttest [$F(1, 41) = 1.18$, $p < .28$, partial $\eta = .028$]. Gilmore also conducted an independent *t*-test to identify the effects of the computer-based instruction on race/ethnicity. The result from the *t*-test indicated that race/ethnicity was not statistically significant [$t(21.52) = -1.77$, $p = .09$, $d = .53$]. From the posttest scores, a statistically significant difference was not observed between African American (M = 691.62, SD = 95.28, n = 37) and Caucasian participants (M = 652.86, SD = 40.15, n = 7).

The study included implications, limitations, and suggestions for future research. Gilmore (2018) identified two implications of the study. One implication was the low-achieving participants could improve mathematical achievement from a computer-based or traditional instruction. Another implication was the small sample size. Gilmore identified five limitations of the study. One limitation was Type II error that caused the small increase in scores from pretest to posttest. Another limitation was the low power caused by a small sample size. The third limitation was instructional time loss due to a hurricane. Participants were displaced and could not complete work. Participants' attendance was another limitation to the study. If students were absent, the missed traditional instruction could not be retaught. A fourth limitation of the study was generalizability; participants in the study were not a representation of the entire school's population. The final limitation was the design of the study. The single pretest-posttest design was created to be used with a single group of students. Gilmore identified the suggestions for future research, which included to increase the sample size and to utilize random selection.

Table 8, below, summarizes studies using a comprehensive meta-analysis to identify the effect of computer-based instruction on student learning. Participants in the studies were Grade 6 through Grade 8 students from the Netherlands, Malaysia, India, Belgium, and the United States. Gilmore (2018) conducted a study on a computer-based instruction (i.e., Math 180). The results from the study indicated that the computer-based instruction did not have a statistically significant impact on student achievement. In contrast, Küçükalkan et al. (2019) analyzed different types of computer-based instruction and determined that computer-managed instruction caused a larger effect on student achievement than any other computer-based instruction.

Table 8

Concept Analysis Chart for the Effects of Computer-Based Instruction

Study	Purpose	Participants	Design/Analysis	Outcomes
Gilmore (2018)	To identify the effect of a computer-based instruction on low-achieving students.	83 middle school students from southwestern Georgia	Correlational Design Pretest-Posttest control group ANCOVA Independent *t* test	No statistically significant effect on participants' STAR Math posttest scores. Male scores improved more than females, but difference was not statistically significant. No statistically significant effect was identified for race/ ethnicity.
Küçükalkan et al. (2019)	To analyze the overall effect size of computer-based instruction on students with	2,290 participants from different countries	Comprehensive meta-analysis software	Computer-managed instruction was the most effective method of computer-

Study	Purpose	Participants	Design/Analysis	Outcomes
	mild learning disabilities.	Analyzed studies from United States (*n* = 15), Belgium (*n* = 2), India (*n* = 1), Malaysia (*n* = 3), and Netherlands (*n* = 10)		based instruction to improve student achievement. Computer-assisted instruction, computer-enriched instruction, and computer-managed instruction generated a medium effect on student achievement in educational settings. Belgium, India, and Malaysia produced large effect, but U.S. and Netherlands generated medium effect sizes on student achievement.

Summary

As a result of the literature review, four types of computer-based instruction, electronic-learning, and gender and student achievement were analyzed. Küçükalkan et al. (2019) conducted a meta-analysis on computer-managed instruction, computer-simulated instruction, computer-enriched instruction, and computer-assisted instruction. From the results of the study, computer-managed instruction was most effective for improving student achievement. Wee et al. (2012) conducted a qualitative study of a computer-managed instruction. Results from the study indicated that the computer-managed instruction was effective and produced learning opportunities for students. Gender and student achievement were also analyzed in the literature review. Fairlie (2016) found that computer use did not impact student achievement and that gender did not affect the achievement gap in student learning. Vate-U-Lan (2017) conducted a quantitative study on e-learning. When students used e-learning games in educational settings, problem-solving skills improved for males, and females experienced anxiety with computer games.

In summary, students were affected by the need for educational technology to be utilized in classrooms. Shapley et al. (2011) stated that laptops helped prepare students for the 21st century, exposed learners to worldwide cultures, expanded learning outside of school, moved students toward product creation, and away from drill and practice for tests. Although Kelly and Rutherford (2017), Earle and Fraser (2017), and Mahmoudi et al. (2015) found that software produced a negative or no effect on student learning, Johnson (2017), Morales (2016), Kiili et al. (2015), and Katmada et al. (2014) determined that specific software could improve student achievement. Research gaps that need to be filled are the impact of gender on student achievement when using computer-managed instructional games, the impact of digital games on different subject areas, and the elements that impact student learning in educational games or software. The purpose of the explanatory sequential mixed methods design was to use the e-learning theory to examine the relationship between i-Ready intervention program and mathematical achievement and to explore teachers' perceptions about implementing the i-Ready program.

CHAPTER III

METHODOLOGY

Educational technology has enriched the learning process to improve students' academic performance (Garneli et al., 2017). A problem exists with using educational software as a mathematics intervention for middle grades students. Given the lack of empirical evidence, one problem is identifying the relationship between a computer-managed instruction (i.e., i-Ready) and middle grades mathematical achievement. The researcher examined the relationship between a computer-managed instruction, i-Ready, and mathematical achievement. The study used an explanatory sequential mixed methods research design to investigate the research problem. In the quantitative phase, the researcher examined the relationship between the gain scores using the pretest and posttest data from i-Ready diagnostic, number of completed lessons, GMAS Mathematics scale scores, and GMAS Mathematics achievement levels. To discover the perceptions of teachers who used the i-Ready intervention program, the researcher utilized standardized open-ended interviews in the qualitative phase.

Purpose of the Study

This mixed methods research study addressed the relationship between the computer-managed instruction, i-Ready, and mathematical achievement as measured by i-Ready diagnostic data and GMAS data. An explanatory sequential research design was used to support the quantitative data with qualitative interview data. In this study, continuous data were used to test the theory of electronic-learning to examine the relationship between the number of completed i-Ready lessons, i-Ready gain scores (i.e., the posttest subtract the pretest), GMAS Mathematics scale scores, and GMAS Mathematics achievement levels for Grade 8 students at a rural middle school in Georgia. The intrinsic case study explored teachers' perceptions of implementing the i-Ready program at a rural middle school in Georgia. The reason for collecting both quantitative and qualitative data was to understand the relationship between the i-Ready intervention program and mathematical achievement. An explanatory sequential mixed methods research study was conducted to answer the following research questions.

1. What is the relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students?

   H_{o1} There is not a relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students.

   H_{a1}: There is a relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students.

2. What is the relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students?

   H_{o2}: There is not a relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

   H_{a2}: There is a relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

3. What is the relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students?

   H_{o3}: There is not a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

$H_{a}3$: There is a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

4. What is the relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students?

   $H_{o}4$: There is not a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

   $H_{a}4$: There is a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

5. What are the average i-Ready gain scores for each GMAS Mathematics achievement level for eighth-grade students?
6. What are middle school mathematics teachers' perceptions of implementing the i-Ready intervention program?

Research Variables

The researcher examined the relationship between the i-Ready intervention program and Grade 8 mathematical achievement. The study attempted to find a relationship, if any, between student assessment scores and the i-Ready intervention program. The variables were the number of completed i-Ready lessons, i-Ready gain scores (i.e., the posttest subtract the pretest), GMAS Mathematics scale scores, and GMAS Mathematics achievement levels (i.e., beginning, developing, proficient) for the 2018-2019 school year. The scale scores provided an overall range of placement levels and ranges per grade level (see Table 9). GMAS Mathematics domain scores, in the form of scale score ranges, indicated the academic achievement levels for each Grade 8 student (see Table 10).

Table 9

i-Ready Overall Placement Scale Score for Grade 8 (2017-2019)

Level	Range
Early	518 - 540
Mid	541 – 574
Late	575 - 585

Note. Data for i-Ready placement for Grade 8 students from Renaissance Learning (2016).

Table 10

Georgia Milestone Assessment System Scale Scores for Grade 8

Level	Range
Level 1	275 - 474
Level 2	475 - 524
Level 3	525 - 578
Level 4	579 - 755

Note. Data for Grade 8 students GMAS Mathematics scale scores range for each level from Georgia Department of Education (2017, 2018).

Research Design

A mixed methods research design was used to collect and combine quantitative and qualitative data. Webb, Campbell, Schwartz, Sechrest, and Grove (1981), Brewer and Hunter (1989), and Johnson and Turner (2003) suggested that researchers thoroughly and purposefully integrated or merged qualitative and quantitative methods, approaches, measures, and concepts. The thorough combination of data depended on the research questions and the concerns of the researcher (Johnson & Christensen, 2019). The study was arranged in two phases (i.e., quantitative and qualitative), and the quantitative phase was emphasized (QUAN→ qual). Johnson and Christensen (2019) stated that the significance placed on the quantitative phase was called the quantitatively driven mixed methods design that emphasized the quantitative perspective and included some qualitative data.

The correlational research included collecting quantitative data to explain an occurrence and solving questions with measurable procedures, such as experiments and surveys (Creswell, 2009). The i-Ready (i.e., pretest and posttest) assessment data, number of completed i-Ready lessons, GMAS Mathematics scale scores, and GMAS Mathematics achievement levels were the quantitative variables for the study. In Phase 1, the study began with identifying students who received Tier II and III intervention services (i.e., 1st percentile through 25th percentile) based on the STAR Math assessment. After identifying the participants, the researcher collected i-Ready pretest and posttest data for the students during the 2018 – 2019 school year. After collecting the i-Ready gain score data, the researcher collected the GMAS Mathematics scale scores and GMAS Mathematics achievement levels for the participants in the study. The researcher used statistical software to conduct a series of bivariate correlation analyses and to analyze the descriptive statistics.

After collecting and analyzing the quantitative data, an intrinsic case study was used to collect qualitative data regarding teacher perceptions in Phase 2. Johnson and Christensen (2019) stated that the intrinsic case study design was utilized to explore a single phenomenon. The researcher used open-ended questions to interview two teachers who implemented the i-Ready intervention program. From the interviews, themes were identified from teacher responses on implementing the intervention program. The quantitative and qualitative research attempted to explain situations and determine patterns or trends throughout the study (Rodriguez, 2013). The researcher explored teachers' perceptions and identified the relationship between a computer-managed instruction (i.e., i-Ready) and Grade 8 mathematical achievement.

Role of the Researcher

The researcher had 10 years of experience teaching middle grades mathematics and has a specialist degree in curriculum and instruction. During the study, the researcher served as the data collector and interviewer of the teacher participants. The researcher was employed previously with the target school as a Grade 8 mathematics teacher who utilized the software in the classroom. No participant had a direct relationship with the researcher that may cause bias in the research study. The researcher gathered the quantitative data and used SPSS statistical software to analyze scientific data. The researcher also coded the teacher interviews and identified themes regarding teacher perceptions about implementing the i-Ready intervention program.

During the researcher's employment with the school, the intervention program, i-Ready was purchased. The school provided limited professional learning, and teachers were required to implement the program with fidelity. The researcher chose to analyze the relationship between the intervention program and mathematical achievement because teachers were not provided with an explanation or supporting research regarding the impact of the program. The researcher also had a child who received Tier II mathematical services and wanted to know if the program was successful in improving student achievement in mathematics.

Participants

Quantitative

The population for the study consisted of students from a rural middle school in southwest Georgia serving 600 students (i.e., 51% males and 49% females) in Grades 6 through 8. The targeted school year included 268 eighth-grade students. The ethnic composition of the 2018 – 2019 school year was 78% African American, 11% Hispanic, 9% Caucasian, and 2% who identified as other (The Governor's Office of Student Achievement, n.d.). The school was a Title I school, and 100% of the students received free/reduced lunch (The Governor's Office of Student Achievement, n.d.). From the population of the school, convenience sampling was used to select all Grade 8 students from the school year who met the inclusion criteria. Participants who were selected for the study received Tier II or III intervention services, completed the i-Ready pretest and posttest, and completed the GMAS Mathematics assessment during the 2018 – 2019 school year.

STAR Math. The STAR Math Enterprise test contained questions from numbers and operations, algebra, geometry and measurement, data analysis, statistics, and probability domains. Based on scale scores and percentile ranks, students were classified as needing urgent intervention, intervention, on watch, and at or above benchmark level. The test contained unlimited questions and was computer-adaptive, meaning the problems changed based on participants' responses (Renaissance Learning, 2016). The results were reported using scaled scores and percentile ranks. Scaled scores assessed student performance over time across grade levels. This score was calculated based on the difficulty of the question and the number of correct replies and ranged from 0 to 1400

(STAR Math Resources, 2019). Percentile rank scores ranged from 1st to 99th and compared the individual student's mathematical skills to other students nationally in the same grade level (STAR Math Resources, 2019). Students who scored between the 11th to 25th percentiles were identified as needing Tier II intervention, and students who scored between the 1st to 10th percentiles were identified as needing Tier III intervention services.

Response to intervention. Students selected to participate in this study were labelled as students receiving response to intervention services. Participants in the study were selected at the beginning of the academic school year by the counselor and mathematics instructional coach. The administrators identified students between the 1st percentile to 10th percentile as requiring Tier III services. These students received a minimum of 140 minutes of additional mathematical intervention time each week in the mathematics lab, which was separate from the general classroom instruction. Students who scored between the 11th percentile to 25th percentile were considered Tier II. These students received a minimum of 90 minutes of supplementary mathematical intervention each week in the mathematics lab, separate from the general classroom.

Response to intervention is a multi-tier support system used to identify instructional needs of struggling learners (Cusumano, Algozzine, & Algozzine, 2014) and identify students with learning disabilities (IDEA, 2004). The multitier system of support combined assessment, instruction, and intervention to address the needs of all learners. Wanzek and Vaughn (2011) stated that response to intervention was used to provide early intervention and decreased the number of students receiving special education services. The model of response to intervention can be two, three, or four-tiered (Mellard et al., 2010). Fuchs, Fuchs, and Compton (2010) explained that the three-tier model consisted of all students in Tier I, targeted intervention was provided to students in Tier II, intense intervention was provided in Tier III, and students receiving special education services were provided in Tier IV (Mellard et al., 2010).

Some Tier II interventions can consist of small group instruction, different instructional interventions, and frequent progress monitoring (Moors, Weisenburgh-Snyder, & Robbins, 2010). For secondary grades, Bouck and Cosby (2017) stated that Tier II intervention can consist of mathematics instruction with a laboratory, small group pull-out, an additional mathematics course, and technology to provide instruction. Vaughn et al. (2010) stated that an intervention elective class could allow students to receive additional mathematical support. Twyman and Sota (2016) specified that Tier II interventions can be transmitted through educational software or programs.

Students who struggled to learn mathematics required supplemental intervention and received additional instruction at the Tier II or Tier III level. Tier II intervention aimed at acquiring and improving knowledge of basic academic skills (Shapiro, 2014). Students who struggled to learn mathematics received Tier II intervention, fell below the expected levels of accomplishment on benchmark assessments, and were at risk of academic failure. Tier III students were considered to have a high risk for academic failure and, if not addressed, students would need special education services (Shapiro, 2014). The difference between Tier II and III was the amount of time students used intervention services. For the study, the researcher used students who were identified as needing Tier II or III mathematical intervention to determine if the i-Ready program impacted student mathematical achievement.

Qualitative

The study also included teachers from the middle school. During the 2018 – 2019 academic year, the school contained 39 certified teachers, with an average of 10 years educational experience. The demographic background was African Americans (*n* = 24), Caucasians (*n* = 13), and Asians (*n* = 2). From the teacher population, purposeful sampling was used to identify participants (*n* = 2) who implemented the i-Ready intervention program in mathematics classrooms. The researcher used two teachers for the study because the teachers implemented the i-Ready program during the 2018 – 2019 school year. During the school year, the teachers were Grade 8 mathematics teachers who were able to provide insight regarding the implementation of the program. In addition, the identified teachers were employed with the school district when the i-Ready intervention program was purchased.

Teachers who were selected to participate in the study monitored students' use on the i-Ready intervention program and provided one-on-one mathematical support. The teachers ensured students were on task and completed mathematical lessons during the required time. In addition, these teachers provided mathematical support to students who struggled to pass a lesson after two attempts. After the second failed attempt, the teachers printed out instructional material from i-Ready and remediated student learning. After remediation, teachers reassigned the lesson for students to complete.

Instrumentation

The following instruments were used to identify student participants and analyze data from the quantitative and qualitative phases. Students who were selected to participate in the study completed the STAR Math assessment, i-Ready diagnostic assessments, and GMAS Mathematics assessment during the 2018-2019 school year. Teachers who were selected to participate in the study were teachers who implemented the i-Ready intervention program during the 2018 – 2019 school year.

STAR Math

The STAR Math assessment was used as a screener to identify student participants. In 1998, Renaissance Learning created a 24-question STAR Math assessment (Renaissance Learning, 2016). Later, in 2011, a 34-question STAR Math assessment was created (Renaissance Learning, 2016). For the STAR Math assessment, students answered 34 mathematical questions, and each question was timed. The students answered a given question, and the program increased or decreased the question's level of complexity. When the level of difficulty changed, the program identified the student's mathematical skill level.

i-Ready Diagnostic

The i-Ready pretest and posttest were administered to all students in the school within the general mathematics classroom. The pretest and posttest contained five to six questions measuring the Common Core standards for each domain. Students completed the same test at the end of the learning segment to determine if there was growth.

Georgia Milestones Assessment System

The final assessment that was completed by all students at the end of the 2018 – 2019 school year was the GMAS. The assessment replaced the CRCT in schools during the 2015 – 2016 academic year (Hudson, 2018). The Georgia Milestones Assessment System was designed to measure how well students acquired skills and knowledge from the Georgia state-mandated academic content standards (Forte, Towles, Greninger, Buchanan, & Deters, 2017). The assessment was composed of an end-of-grade component for Grades 3 through 8) and an end-of-course component for Grades 9 through 12. Performance on the GMAS was classified into one of four achievement levels (i.e., beginning learner, developing learner, proficient learner, and distinguished learner; Forte et al., 2017). The assessment provided information on academic achievement at the student, class, school, system, and state levels. Hudson (2018) identified that the assessment measured Grade 8 student knowledge on geometry (28%), statistics and probability (12%), numbers, expressions, and equations (20%), and algebra and functions (20%). Table 11 presents literature that supported the inclusion of elements in the data collection instruments.

Table 11

Quantitative Item Analysis

Item	Research	Research Question
1. Number sense	Whitacre & Nickerson (2016); Young et al. (2017)	3, 4, 5
2. Number of completed lessons	Savvani (2018)	1, 2, 3, 4
3. Geometry	Ayan & Isiksal-Bostan (2019)	1, 4, 5
4. Algebra	Moss & Lamberg (2019)	2, 4, 5

Reliability and Validity

When testing an instrument, reliability and validity are two analytical properties of the test. Reliability is the stability and consistency of participants' test scores on an instrument used to assess the same items (Worthen, White, & Sudweeks, 1999). Research reliability occurs when the results from a study could be repeated if the study was conducted again (Johnson & Christensen, 2019). Reliability was calculated with a correlational coefficient called the reliability coefficient (Johnson & Christensen, 2019). Johnson and Christensen (2019) identified that the instrument is considered reliable when the coefficient is close to +1.00. Research validity is the precision of the conclusions, explanations, or procedures that were created from the instrument (Johnson & Christensen, 2019). Validity refers to the accuracy or dependability of assumptions made from the results of the study (Johnson & Christensen, 2019).

STAR Math. Renaissance Learning (2016) used generic, split-half, test-retest, and alternate forms reliability to measure consistency of the instrument. Generic reliability measures upper-bound estimates of the internal consistency of the STAR Math instrument (Renaissance Learning, 2016). The generic reliability coefficient of the STAR Math test was high ($\alpha = .93$) for Grade 8 students (Renaissance Learning, 2016). Split-half reliability is the estimate of internal correlation between two equivalent halves of the same test (Johnson & Christensen, 2019; Renaissance Learning, 2016). Johnson and Christensen (2019) stated that the alpha coefficient should be greater than .70. A low coefficient would indicate that the instrument was unreliable and contained measurement error, and a high coefficient would indicate that the test was reliable (Johnson &

Christensen, 2019). The split-half reliability coefficient for the STAR Math test was high ($\alpha = .93$) for Grade 8 students (Renaissance Learning, 2016).

Alternate forms reliability is measured when two different forms of a test are administered to students. The students answered two versions of a test with the same number of questions, difficulty, and skills, but the versions contained different test items (Johnson & Christensen, 2019). The coefficient for alternate form was .84 for Grade 8 students (Renaissance Learning, 2016). Test-retest reliability was used to measure the consistency of the instrument (Renaissance Learning, 2016).

Test-retest reliability is measured by administering a test twice to the same participants (Johnson & Christensen, 2019). The correlational coefficient would be high (i.e., reliable) if the same participants who received high scores on the first administration also received high scores on the second administration. The test-retest coefficient was .84 for Grade 8 students (Renaissance Learning, 2016). When assessing the test-retest reliability, the time that elapsed between administrations impacts the correlational coefficient (Renaissance Learning, 2016). The average number of days between STAR Math test administrations should be 100 for Grade 8 students (Renaissance Learning, 2016). If the time between test administrations was too short, scores could be similar, and, if the time interval was too long, participants could learn new skills or forget content (Johnson & Christensen, 2019).

Renaissance Learning (2016) utilized concurrent and predictive validity to measure the dependability of the STAR Math assessment. Concurrent validity is measured by the correlations between STAR Math scores and other tests that were administered within a two-month time period between 2002 and 2016. The average concurrent validity coefficient was .74 for Grade 8 students (Renaissance Learning, 2016). The predictive validity is an estimate of how the STAR Math score will predict a student's score on a criterion test. The STAR Math instrument was valid to determine mathematical placement. The mathematical predictive validity coefficient was .74 for Grade 8 students (Renaissance Learning, 2016).

i-Ready diagnostic. According to Curriculum Associates (2015c), i-Ready was an intervention that provided differentiated K–8 student online and teacher-led instruction and was a valid and reliable K–12 diagnostic. Bunch (2017), Curriculum Associates (2015c, 2017), and Ezzelle (2017) identified the i-Ready diagnostic as a valid and reliable tool to make inferences about students' knowledge and how students would perform in a certain area. The i-Ready data identified where students struggled, provided validity and reliability in growth measures, and differentiated instruction based on the data (Curriculum Associates, 2016).

To examine the validity of the i-Ready Diagnostic, Educational Research Institute of America (2018) used statistical procedures to measure the correlations between the GMAS in mathematics. The 2017 spring correlation coefficient for mathematics was .72 for Grade 8 students. In addition, the correlations were high across all i-Ready testing periods, were statistically significant ($p < .0001$), and exceeded the Center on Response to Intervention's minimum limit for relationships (i.e., $r = .70$). The strong correlations indicated that i-Ready Diagnostic and GMAS were evaluating comparable content and provided strong evidence of validity of the i-Ready assessments as a measure of students' development toward obtaining the knowledge and skills evaluated by the Georgia Standards of Excellence (Educational Research Institute of America, 2018).

GMAS Mathematics. Reliability for the GMAS Mathematics is determined by the degree to which the students' test scores are consistent and stable over time (Hudson, 2018). A reliable assessment would produce steady scores if Grade 8 students completed the same test without exhaustion or impacts to recall (Hudson, 2018). The Cronbach alpha reliability analysis determined the consistency of test scores for the 2018 – 2019 school year, and the alpha coefficient for Grade 8 students was .91 (Georgia Department of Education, 2018, 2019b).

Georgia Department of Education (2017) stated that validity is established by the development and purpose of the assessment. Validity also relies on how well the instrument pairs with content standards and how the reported results inform shareholders (i.e., students, parents, and educators) about students' performance (O.C.G.A. 20-2-281). GMAS items were validated by professional assessment specialists. The specialists reviewed item alignment to the curriculum, revised items, and rejected items.

Qualitative

Open-ended questions were used in research to discover, clarify, and/or strengthen existing ideas (Jackson & Trochim, 2002). When concepts were not identified, open-ended questions provided knowledge to develop other research fields (Lee & Lutz, 2016). With open-ended questions, researchers could uncover concepts that closed-ended questions did not address. The researcher interviewed teacher participants using the teacher interview protocol. The researcher utilized 12 predefined items, developed by the researcher, to interview the participants. Four items were developed to identify the educators' background, and eight items were developed to obtain teachers' perceptions on implementing the i-Ready intervention program. The questions were asked in the same order to all interviewees. Consistency of the interview was used to reduce the effects of the instrument and researchers' bias on the results of the study (Zhang & Wildemuth, 2009).

Member checking and intracoder reliability were used to establish the reliability and validity of the open-ended questions. Intracoder reliability was used to ensure that the individual coder was consistent when coding the data (Johnson & Christensen, 2019). Member checking was used to allow participants to review the transcribed interviews and make any necessary corrections (Johnson & Christensen, 2019). Table 12 presents literature that supported the inclusion of items within the qualitative instrument.

Table 12

Qualitative Item Analysis

Item	Research	Interview Question	Research Question
1. Features of i-Ready that work well	Cho et al. (2018)	4, 5	6
2. Features of i-Ready that need modifications	Callaghan et al. (2018)	4, 6	6
3. Challenges of implementation	Berggren et al. (2018)	4, 7	6
4. Benefits of implementation	Johnson & Smith (2008)	4, 8	6
5. Contributing factors for low-student achievement	Alrabai (2016); Bellibas (2016)	4, 9	6
6. Contributing factors for high-student achievement	Walstad & Soper (1989)	4, 10	6
7. Perceptions about program	Bippert & Harmon (2017)	11, 12	6
8. Educators' title	Ellis & Travis (2007)	1	6
9. Years of experience in education	Klassen & Chiu (2010)	2	6
10. Years of experience in current role	Klassen & Chiu (2010)	3	6

Intervention

Participants who scored between the 1st and 25th percentiles on the STAR Math assessment participated in the i-Ready mathematics intervention. In 2010, Curriculum Associates created the program to integrate assessment, create engaging instruction, and individualize student learning in mathematics. The program contained an online toolbox of resources from kindergarten to eighth-grade mathematics to provide students with differentiated instruction. The instructional content included standardized activities, interactive whiteboard activities, assessments, and learning videos (Curriculum Associates, 2016). The online instructional modules in i-Ready Instruction provided specialized instructional content based on the results from diagnostic assessments. The instructional segments were created for different learning styles and abilities. Curriculum Associates (2015a) stated that the instruction appeared to happen in real-life and was accessible and enjoyable for student learning.

Grade 8 student participants completed the mathematical intervention on Georgia Standards of Excellence mathematical domains (i.e., numbers and operations, algebra and algebraic thinking, measurement and data, and geometry). The activities for the numbers and operations domain allowed participants to demonstrate understanding of integers and real numbers (Curriculum Associates, 2015a). After the participants completed the algebra and algebraic thinking domain activities, knowledge on expressions, equations, and functions should improve (Curriculum Associates, 2015a). The activities allowed students to utilize graphing tools to display representations of situations. With the measurement and data domain, participants completed activities on statistics and probability. The activities allowed the participants to demonstrate conceptual understanding with bivariate data sets by graphing linear functions (Curriculum Associates, 2015a). After completing geometry domain activities, the participants' understanding of geometric measurement was demonstrated (Curriculum Associates, 2015a).

The student participants completed the i-Ready intervention in a mathematics lab and in a mathematics teacher's classroom. Participants completed the pretest in the general mathematics classroom. After the pretest, participants received i-Ready intervention in a mathematics laboratory, exploratory class two to three times a week. Participants completed intervention lessons for 18 weeks, for a minimum of 60 minutes per week. Additionally, all students in the school received 30 minutes of i-Ready intervention in regular classrooms two to three times a week. After receiving the intervention, participants completed the i-Ready posttest during the general mathematics classroom. At the end of the school year, participants completed the GMAS Mathematics assessment.

Data Collection

Before collecting data for the study, a human subjects research application was submitted to the Institutional Review Board (IRB) at Columbus State University (Creswell, 2013). Once the IRB approved the study, an IRB approval email (Appendix A) was sent to the researcher. After the researcher was approved to conduct the study, an email request (Appendix B) was sent to the school system's superintendent to gather the i-Ready and Georgia Milestones Assessment data. The researcher provided the school district with a written consent form to participate in the study, which contained the purpose and benefits of the study.

Phase 1: Quantitative

In Phase 1, the quantitative data included the i-Ready diagnostic data (i.e., pretest scores, posttest scores, and number of completed lessons), GMAS Mathematics scale scores, and GMAS Mathematics achievement levels for the 2018 – 2019 school year. Once authorized (Appendix C), the researcher emailed (Appendix D) the assistant superintendent a request to release data from i-Ready and GMAS scores. The assistant superintendent provided the researcher the 2018 – 2019 GMAS scores for each mathematical domain via a password-protected Excel spreadsheet. Once authorized to receive the i-Ready data, the researcher requested permission from the school district's response to intervention specialist to retrieve the 2018 – 2019 i-Ready pretest and posttest diagnostic data for each mathematical domain, participants' gender, and number of completed lessons. The response to intervention specialist also provided the researcher with requested data via email using a password-protected Excel spreadsheet.

Several steps were taken to protect the participants' privacy and confidentiality. First, the study site and participants were given pseudonyms to protect true identities (Bogdan & Biklen, 2016). Additionally, the true identities of the school, district, and participants were not revealed in written or verbal reporting (Bogdan & Biklen, 2016). Lastly, after the analysis of data, the electronic data were stored in a locked filing cabinet in the researcher's home for 5 years. After 5 years, the electronic data will be terminated through protected erase (American Psychological Association, 2010).

Phase 2: Qualitative

In Phase 2, the qualitative data were collected from teachers who volunteered to participate in the interviews. Whenever research is conducted that involves human participants, specific ethical considerations arise (Merriam & Tisdell, 2016; Yin, 2018). Based on the 1979 Belmont Report, researchers must consider ethical concerns when conducting research (Vollmer & George, 2010). Every Grade 8 (n = 2) mathematics teacher in the selected school had the opportunity to volunteer for participation in a one-on-one interview about their perceptions of the i-Ready implementation. A recruitment email (Appendix E) was sent to prospective participants, which included the informed consent form (Appendix F). Participating teachers signed an informed consent form that included the researcher's contact information, elements of the study, rights of the participants, guarantee of participant anonymity and confidentiality, and participants' predicted time commitment. To protect the precision of the information, participants did not receive gifts, tokens, or rewards for participating in the study. After signing the informed consent form, the participants emailed the signed document to the researcher's email, and the researcher scheduled the interview and sent the GoToMeeting conference link to join the interview session.

Before conducting the interviews, participants were informed that the researcher was recording and transcribing the interview. The meeting was recorded with GoToMeeting, and a tape recorder was used as a back-up device. The researcher conducted one-on-one virtual interviews, which lasted approximately 30 minutes, using the GoToMeeting conference tool with each participant, and utilizing the teacher interview protocol (Appendix G). The interview was conducted after instructional hours.

The researcher had access to all the interview tapes, recording, and transcripts. The results of the study were not to be attached to the school district, and the researcher used pseudonyms for all participants in the report. Only the researcher had access to the interview data, which was in a locked cabinet and/or on a hard drive that was password protected for 5 years after the dissertation is published. After 5 years, the researcher will shred and permanently delete all data.

Data Analysis

Merriam (2009) stated that data analysis was "the process of making sense out of the data" (p. 178), suggesting that making sense requires the researcher to read, review, organize, and then ultimately interpret. The researcher collected quantitative findings and reported the results in tables. The researcher collected qualitative results and described the findings in text and charts.

Quantitative

To analyze the quantitative data, the researcher uploaded the participants' gender, i-Ready pretest scores, i-Ready posttest scores, number of completed i-Ready lessons, GMAS Mathematics scale scores, and GMAS Mathematics achievement levels into SPSS. Gatlin (2009) identified that SPSS was a 28-tool used to analyze data in the social sciences or business research.

To analyze the quantitative data, the researcher used the SPSS software to conduct bivariate correlation analyses and to analyze the descriptive statistics. The Pearson correlation coefficient (r) was conducted to determine if the quantitative variables were associated. Ravid (2019) stated that the strength or degree of a correlation is indicated by the correlation coefficient. Sari et al. (2017) identified that the scale value for the coefficient ranges from -1.00 (i.e., perfect negative correlation) through 0 (i.e., no correlation) to +1.00 (i.e., perfect positive correlation). Correlations that are less than .10 are measured as insignificant, weak correlations range from .10 to .30, moderate correlations range from .30 to .50, and strong correlations are above .50 (Cohen, 1988; Field, 2013). A positive correlation occurs when the variables from the two scores move in the same direction. A negative correlation occurs when the scores from the variables move in opposite directions (Johnson & Christensen, 2019).

Assumptions. Pedhazur (1997) stated that "knowledge and understanding of the situations when violations of assumptions lead to serious biases, and when they are of little consequence, are essential to meaningful data analysis" (p. 33). If assumptions were not met, the results from the study could cause "Type I or Type II errors, or over- or under-estimation of significances or effect size(s)" (Osborne & Waters, 2002, p. 1).

The first assumption, measurement scales, was analyzed based on the types of data used in the statistical software. Pearson correlation coefficient was calculated with normally distributed continuous variables (Akoglu, 2018). If the data contained ordinal variables, the correlation coefficient should be conducted with a Spearman correlation instead of a Pearson correlation (Akoglu, 2018).

The next assumptions, linearity, pairs in the data, and outliers were analyzed with a scatter plot. A scatter plot is a graphical display of a relationship between two variables (Ravid, 2019). Each point on the scatter plot represents one participant and the corresponding score. The scatter plot could represent a negative, positive, or no correlation. In a negative correlation, an increase in one variable is associated with a decrease in the other variable. In a positive correlation, an increase is associated with both variables. When the scatter plots produces no correlations, the points do not form a clear pattern and are widely scattered (Ravid, 2019). In addition, the scatterplot is used to locate pairs and outliers in the data. A scatter plot is utilized to identify scores that are significantly different from the other scores (Ravid, 2019). The removal of bivariate outliers reduces the probability of Type I and Type II errors and improves truthfulness of estimations (Osborne & Waters, 2002).

Linearity was analyzed with the scatter plot. Ravid (2019) stated that the two correlating variables should have a linear relationship (i.e., positive or negative correlation). Osborne and Waters (2002) stated that linearity occurs when the predicting variables have a direct correlation with the outcome variable. If linearity is not achieved, the results of the analysis over-estimate the correlation and increase Type I errors (Cameron et al., 2019).

Descriptive statistics. The SPSS statistical software was used to conduct descriptive statistics for the variables (i.e., i-Ready gain scores, number of completed i-Ready lessons, GMAS Mathematics scale scores, and GMAS Mathematics achievement levels). Teddlie and Tashakkori (2009) described descriptive statistics as the investigation of mathematical data to find “summary indicators that can efficiently describe a group and the relationships among the variables within that group” (p. 24).

Bivariate correlation analysis. A series of bivariate correlation analyses was conducted to examine the relationship between the i-Ready intervention program and students’ mathematical achievement as measured by 2018 – 2019 GMAS Mathematics scale scores. A bivariate correlation is an analysis that measures the strength of relationship between two variables through the calculation of correlation coefficients. A correlational analysis was used to model the relationship between students’ performance on the i-Ready diagnostic assessments, the number of completed i-Ready lessons, and GMAS Mathematics scale scores. Akoglu (2018) stated that the correlation analysis is an interrelationship measure between two variables that does not establish reason and outcome. When the correlation coefficients demonstrate a significant relationship between the variables, a disparity occurs within the variables (Akoglu, 2018). The value of the correlation coefficients ranges between -1 and +1, and the closer the correlation coefficient is to zero, the weaker the relationship (Akoglu, 2018). Regarding the direction of the relationship, a positive sign indicates a positive relationship, while a negative sign indicates a negative relationship. To answer Research Question 1, the researcher conducted a bivariate correlation using the number of completed lessons and number sense i-Ready gain scores and analyzed the descriptive statistics of the variables. To answer Research Question 2, the researcher conducted a bivariate correlation using the number of completed lessons and geometry i-Ready gain scores and analyzed the descriptive statistics of the variables. To answer Research Question 3, the researcher conducted a bivariate correlation using the number of completed lessons and algebra i-Ready gain scores and analyzed the descriptive statistics of the variables. To answer Research Question 4, the researcher conducted a bivariate correlation between the number of completed lessons and the GMAS Mathematics scale scores and analyzed the descriptive statistics of the variables. To answer Research Question 5, the researcher analyzed the descriptive statistics using the average i-Ready gain scores for each GMAS Mathematics achievement level.

Qualitative

To analyze the qualitative data, one-on-one interviews were audio recorded and transcribed by the researcher. The researcher recorded the interview and used GoToMeeting dictation to transcribe the interview. The researcher reviewed the transcribed dictation from GoToMeeting and compared the recorded interview to the transcription. The researcher made corrections to the transcription after comparing the data with the recorded interview. The researcher used three stages to code the data. In Stage 1, open coding was used to examine the transcript, line by line, and categorize the distinct elements in the data (Johnson & Christensen, 2019). The researcher used “words or short phrases from the participant’s own language in the data record as codes” (Miles et al., 2014, p. 74), which required the researcher to use interviewees’ exact language. Hand transcribing and coding were used for the qualitative case study research. The utilization of hand coding allowed the researcher to connect the data while understanding the participants’ voice. During Stage 2, after categorizing the elements, the researcher used axial or pattern coding. Johnson and Christensen (2019) stated that axial coding was used to expand and organize concepts into groups. Axial coding identifies “a category’s properties and dimensions and explores how the categories and subcategories relate to each other” (Saldaña, 2016, p. 236). During this stage, the researcher identified phenomena mentioned numerous times by the participants during the interviews. The researcher also examined possible relationships between the data. Saldaña (2016) stated that pattern coding identifies “repetitive, regular, or consistent occurrences [of data] that appear more than twice” (p. 5). Subsequently, pattern coding allowed the researcher to “group summaries into a smaller number of categories, themes, or constructs” (Miles et al., 2014, p. 86). In Stage 3, selective coding, the researcher analyzed data by reviewing the results from Stage 1 and Stage 2. The researcher focused on the central idea by identifying details and rechecking the theory to ensure theoretical saturation did not occur

(Johnson & Christensen, 2019). The researcher used the data to explore participants' perceptions of implementing the i-Ready intervention program.

After transcribing and coding the interviews to identify teachers' perceptions of implementing the i-Ready program, member checking was used. Member checking was used to allow the participants an opportunity to review the transcripts and to approve the comprehensive analysis and placement of replies (Johnson & Christensen, 2019). Lincoln and Guba (1985) stated that member checking should occur during the interview or near the end of the research project. Member checking can be used to increase validity or credibility of research (Iivari, 2018). Member checking invites participants to contribute to the research process and assist the researcher to compose outcomes from the data (Iivari, 2018). After the interview, the researcher emailed participants (Appendix H) their transcribed interview to allow participants to review the authenticity of the results. The participants checked to determine whether an accurate representation was made of what she conveyed during the interview. To answer Research Question 6, the researcher analyzed the coded themes and patterns from the interviews.

Trustworthiness. The validity of qualitative research relies on the accuracy of the outcomes of perspectives from researchers, participants, and readers (Creswell & Miller, 2000). Therefore, trustworthiness is an aspect used in qualitative research. Lincoln and Guba (1985) stated that trustworthiness includes the principles of internal and external validity, objectivity, and reliability. Lincoln and Guba (1985) and Merriam and Tisdell (2016) indicated that credibility is a crucial component of trustworthiness and identifies methods to ensure a study's reliability, including length of time for observations, triangulation of data, reporting negative case analysis, peer interviewing, member checking, and reflexivity.

Credibility. Credibility, or internal validity, ensures that the study measured the intended concepts. Strategies to improve credibility included member checking and the background of the researcher. Maxwell (2013) stated that member checking eliminates the misinterpretation of results, confirms the participants' perspectives, and identifies any researcher bias. Member checking involves the researcher sharing the findings with the participants to analyze the transcribed interview and comment on the results (Creswell, 2007).

Transferability. Lincoln and Guba (1985) identified that transferability or generalizability is the capability to apply concepts of the study to other contexts. The transferability of this study to potential studies is decided by future investigators (Lincoln & Guba, 1985). The researcher provided adequate descriptive data for future researchers to make this determination (Lincoln & Guba, 1985). Although this study was a single case study and could not be generalized, this study could be used if potential sample populations contained the same demographic variables.

Dependability. According to Lincoln and Guba (1985), dependability is the ability to determine if the results of a study could be repeated. The researcher established dependability with interview notes and recordings. The notes included traceable procedures and documents that represented the research process.

Confirmability. Lincoln and Guba (1985) identified that confirmability is established in a study by the level of objectivity. To ensure confirmability, the researcher focused on the qualitative and quantitative data, as opposed to the neutrality of the researcher (Lincoln & Guba, 1985). Additionally, the researcher provided a detailed explanation of the steps that were involved in the research process and highlighted the researcher's perspective and potential bias.

Integration

Integration of mixed methods research involves combining quantitative and qualitative data that lead to thorough knowledge of a topic (Bryman, 2006; Caracelli & Greene, 1997; Creamer, 2018; Fetters et al., 2013). Quantitative results and qualitative themes were compared through a quantitative driven design (Johnson & Christensen, 2019). The researcher utilized quantitative data and included supplemental qualitative components without changing the overall approach to research (Johnson & Christensen, 2019). In Phase 1, i-Ready diagnostic data, GMAS Mathematics scale scores, and GMAS Mathematics achievement levels from eighth-grade students were analyzed using bivariate correlations and descriptive statistics. In Phase 2, the researcher interviewed teacher participants who implemented the i-Ready intervention program. From the coded data, the researcher identified common themes and patterns.

The researcher merged quantitative and qualitative data with joint displays, using the research question-by-outcome joint display. The display included columns that were entitled theme, research question, quantitative outcome, qualitative themes, and an integrated statement. The researcher inputted the research questions in the table and utilized quantitative and qualitative results to answer the questions. After inputting the research questions, the researcher recorded the quantitative and qualitative results for each research question. Finally, the researcher included an integrated statement to explain the theoretical importance, implications, and reasons for similarities or differences.

Following the completion of the joint display, the researcher examined the i-Ready intervention program and Grade 8 students' mathematical achievement.

Summary

The researcher used an explanatory sequential mixed methods research design to examine the relationship between the i-Ready intervention program and students' mathematical achievement and to explore teachers' perceptions of implementing the i-Ready intervention program. In this chapter, the researcher described the research design, population sample, data collection instruments, intervention, and procedures to conduct the research. Additionally, the researcher identified how trustworthiness was established to protect human subjects. In Chapter IV, the results of the mixed methods research study will be reported by research questions using the statistical test results in the quantitative phase, and coded patterns and themes in the qualitative phase.

CHAPTER IV

RESULTS

A problem exists in using educational software as an intervention for middle grades mathematics. The purpose of the study was to examine the relationship between the i-Ready program and students' mathematical achievement and to explore teachers' perceptions of implementing the i-Ready intervention program. To investigate the research problem, the researcher used an explanatory sequential mixed methods research design. In the quantitative phase, the researcher examined the relationship between the gain scores using the pretest and posttest data from i-Ready diagnostic, number of completed lessons, GMAS Mathematics scale scores, and GMAS mathematical achievement levels. The researcher utilized statistical software to conduct and analyze descriptive statistics and bivariate correlation analyses. For the qualitative phase, the researcher used standardized open-ended interviews to explore the perceptions of teachers who implemented the i-Ready intervention program. The quantitative and qualitative data were merged and presented in a joint table.

Participants

Quantitative Phase

To collect the quantitative data (i.e., i-Ready pretest scores, i-Ready posttest scores, number of completed i-Ready lessons, GMAS Mathematics scale scores, and GMAS Mathematics achievement levels), the researcher sent an email to the response to intervention specialist (Appendix I) and the assistant superintendent (Appendix D). After 19 days, the response to intervention specialist emailed the i-Ready data, and the assistant superintendent emailed the GMAS data. Both sets of data were emailed to the researcher as a password-protected Microsoft Excel document. After the researcher screened the data, 48 student participants met the inclusion criterion. The inclusion criterion included students who received Tier II or III intervention services, completed the i-Ready pretest and posttest, and completed the GMAS Mathematics assessment during the 2018 – 2019 school year. The participants included 25 females (52.1%) and 23 males (47.9%).

From the selected sample, 31 participants (64.6%) were classified as receiving Tier II services, and 17 participants (35.4%) were classified as receiving Tier III intervention services. From the selected sample of participants who received Tier II intervention services, 13 (41.9%) were males, and 18 (58.1%) were females. The participants who received Tier III intervention services included 10 (58.8%) males and 7 (41.2%) females. Table 13 presents the RTI demographics for the participants.

Table 13

RTI Demographics of Participants

	Males		Females	
Tier	*n*	%	*n*	%
Tier II	13	41.9	18	58.1
Tier III	10	58.8	7	41.2

Qualitative Phase

To collect the qualitative data, the researcher emailed mathematics teachers who taught eighth grade during the 2018 – 2019 school year. The researcher sent teacher participants a recruitment email to seek participation in the study. Immediately, Teacher A responded agreeing to participate in the study. After four days, Teacher B responded agreeing to participate in the study. After the researcher received the confirmation emails, an informed consent form was emailed to the participants. Teacher A signed the consent form and returned the form to the researcher after five days. Teacher B signed the consent form and returned the form to the researcher the same day after receiving the form. Teacher A informed the researcher the virtual interview could be conducted eight days from the receipt of the consent form. In the email, Teacher A included the possible date and time to conduct the interview. Teacher B informed the researcher that the virtual interview could be conducted one day from the receipt of the consent form. In the email, Teacher B included the possible date and time to conduct the interview. The researcher replied to the participants' emails with the GoToMeeting link that was used to conduct the individual interviews.

The researcher interviewed two female teachers (i.e., Teacher A and Teacher B) who taught Grade 8 mathematics at the participating school. Teacher A was the mathematics department chair, a team leader, and a member of the vertical alignment team. Teacher A had 15 years of experience as a Grade 8 mathematics teacher and six additional years of teaching experience in other content areas. Teacher B was an exploratory teacher for students who struggled with learning mathematics. Teacher B was identified as a mathematics support teacher who had 21 years of educational experience with working in other content areas and four years of experience working as the Grade 8 mathematics support teacher.

The researcher interviewed Teacher A and Teacher B with the GoToMeeting software. Participant attrition did not occur in the study, and both teacher participants completed the virtual interviews. The virtual interviews were completed within a 30-minute time frame and were recorded with the GoToMeeting software. The researcher also utilized the software to transcribe the interviews initially, then the researcher reviewed the transcribed data and compared the initial transcription to the recording. The researcher listened to the recording and corrected words or phrases that were incorrect within the initial transcription. After correcting the transcribed data, the member checking email (Appendix H) and transcribed interview were sent to the participants. After 30 days, the participants responded back that the transcribed data were correct, and no corrections were needed.

Findings

Research Question 1: What is the relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students?

To answer the Research Question 1, a correlational analysis was conducted to determine the relationship between the number of completed i-Ready lessons and the number sense i-Ready gain scores. Student participants completed the i-Ready diagnostic two times (i.e., pretest and posttest) during the 2018 – 2019 school year. After the pretest, the i-Ready intervention program created individualized lessons for the students to complete. The lessons included integrated content from the number sense, geometry, and algebra domains. Participants completed lessons in mathematics classrooms and labs. Toward the completion of the 2018 – 2019 school year, students completed the posttest.

Descriptive statistics were conducted to describe and summarize the number of completed i-Ready lessons and number sense i-Ready gain scores. For the variables, the researcher reported the mean (*M*), range, and standard deviation (*SD*). There were 48 students who completed i-Ready lessons and obtained an i-Ready number sense gain scores. The mean value of the number of completed i-Ready lessons was 30.03 with a standard deviation of 21.21. The number of completed lessons ranged from 0 to 81. The number sense i-Ready gain scores mean value was 0.71 with a standard deviation of 42.48. The gain scores ranged from -108 to 95.

A bivariate correlation was conducted to measure if there was a relationship between the number of completed i-Ready lessons and number sense gain scores. The researcher conducted a Pearson *r*. Correlational coefficients between .00 and .33 are characterized as weak, coefficients between .34 and .66 are considered moderate, and coefficients between .67 and 1.00 are determined to be high (Ravid, 2019). There was a weak negative relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores, $r(46) = -\ .18$. After analyzing the bivariate correlation, a scatter plot was used to display the data (Figure 1). The scatter plot displayed a linear negative relationship, as the number of completed i-Ready lessons increased, the number sense gain score decreased. Following the analysis of the bivariate correlation and the scatter plot, the researcher rejected the null hypothesis and concluded that a weak and negative relationship existed between the number of completed i-Ready lessons and numbers sense i-Ready gain scores for eighth-grade students.

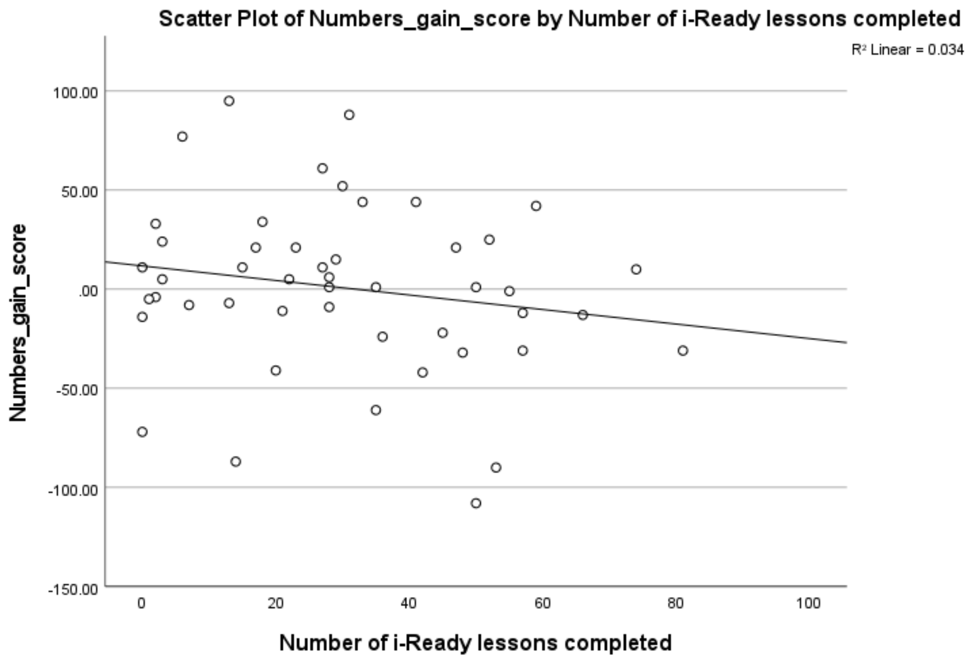

Figure 1. Scatter plot for number of completed i-Ready lessons and number sense gain scores.

Research Question 2: What is the relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students?

To address the Research Question 2, a correlational analysis was conducted to determine the relationship between the number of completed i-Ready lessons and the geometry i-Ready gain scores. Student participants completed the i-Ready diagnostic two times (i.e., pretest and posttest) during the 2018 – 2019 school year. After the pretest, the i-Ready intervention program created individualized lessons for the students to complete. The lessons included integrated content from the number sense, geometry, and algebra domains. Participants completed lessons in mathematics classrooms and labs. Toward the completion of the 2018 – 2019 school year, students completed the posttest.

Descriptive statistics were conducted to describe and summarize the number of completed i-Ready lessons and geometry i-Ready gain scores. For the variables, the researcher reported the mean (*M*), range, and standard deviation (*SD*). The geometry i-Ready gain scores had a mean of -6.35 with a standard deviation of 38.88. The gain scores ranged from -116 to 78.

A bivariate correlation (i.e., Pearson *r*) was conducted to analyze the relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores. A relationship did not exist between the number of completed i-Ready lessons and the geometry gain scores, $r(46) = .059$. After analyzing the bivariate correlation, a scatter plot was used to present the data (Figure 2). The scatter plot did not reveal a correlation between the number of completed i-Ready lessons and the geometry i-Ready gain scores. Following the analysis of the bivariate correlation and the scatter plot, the researcher failed to reject the null hypothesis and concluded that a relationship did not exist between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

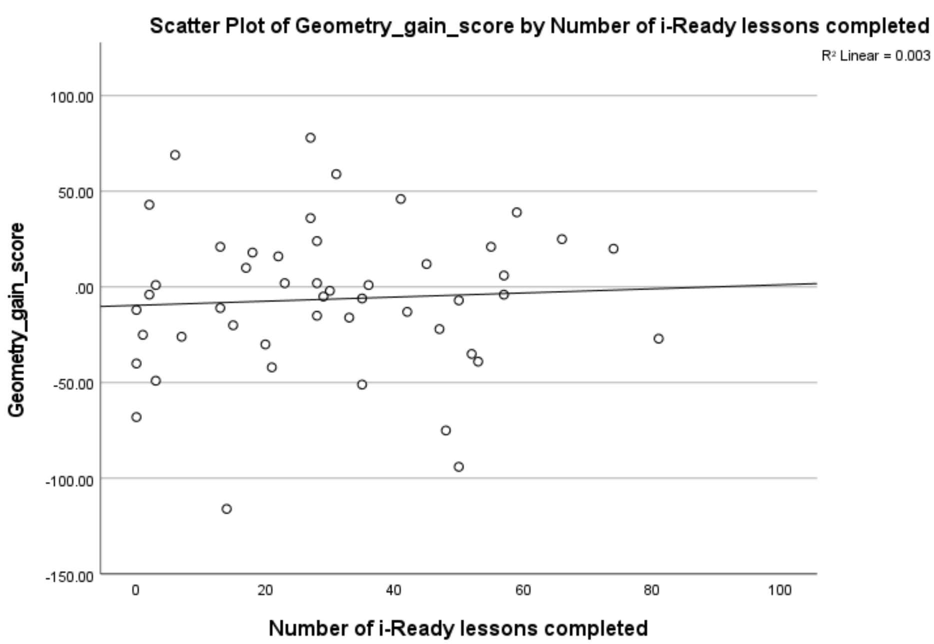

Figure 2. Scatter plot for number of completed i-Ready lessons and geometry gain scores.

Research Question 3: What is the relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students?

To address Research Question 3, the researcher conducted a correlational analysis to determine the relationship between the number of completed i-Ready lessons and the algebra i-Ready gain scores. Student participants completed the i-Ready diagnostic two times (i.e., pretest and posttest) during the 2018 – 2019 school year. After the pretest, the i-Ready intervention program created individualized lessons for the students to complete. The lessons included integrated content from the number sense, geometry, and algebra domains. Participants completed lessons in mathematics classrooms and labs. Toward the completion of the 2018 – 2019 school year, students completed the posttest.

Descriptive statistics were conducted to describe and summarize the number of completed i-Ready lessons and algebra i-Ready gain scores. For the variables, the researcher reported the mean (*M*), range, and standard deviation (*SD*). The algebra i-Ready gain scores had a mean of -5.45 with a standard deviation of 39.27. The gain scores ranged from -79 to 80.

A bivariate correlation (i.e., Pearson *r*) was conducted to analyze the relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores. A weak and positive relationship existed between the number of completed i-Ready lessons and algebra i-Ready gain scores, $r(46) = .19$. After analyzing the bivariate correlation, a scatter plot was used to display the data (Figure 3). The scatter plot displayed a linear positive relationship, as the number of completed i-Ready lessons increased, the algebra gain score also increased. Following the analysis of the bivariate correlation and the scatter plot, the researcher rejected the null hypothesis and concluded that there was a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

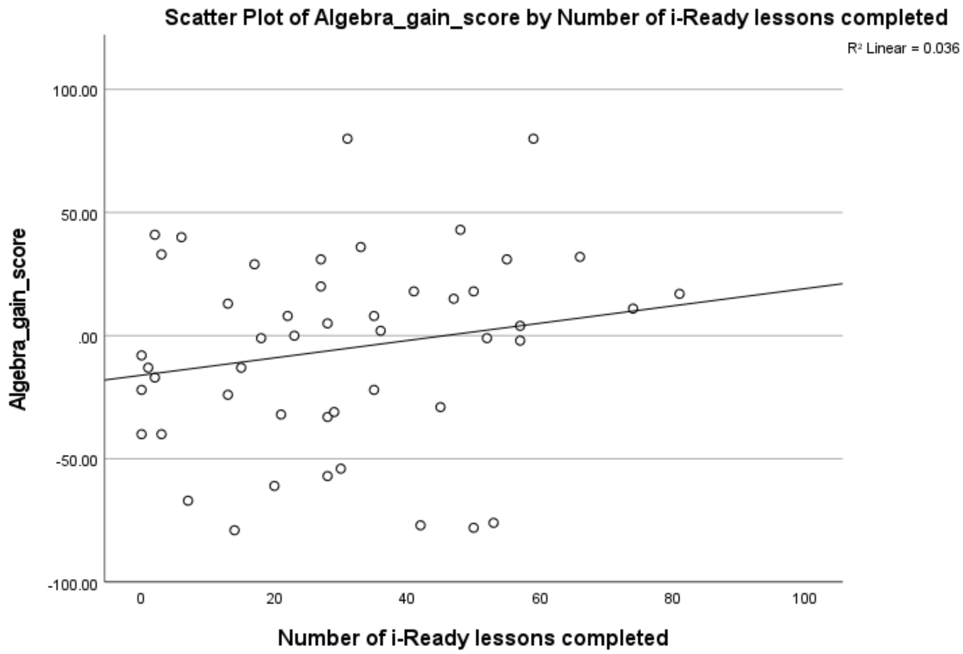

Figure 3. Scatter plot for number of completed i-Ready lessons and algebra gain scores.

Research Question 4: What is the relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students?

To address Research Question 4, the researcher conducted a correlational analysis to determine the relationship between the number of completed i-Ready lessons and the GMAS Mathematics scale scores. After the pretest, the i-Ready intervention program created individualized lessons for the students to complete. The lessons included integrated content from the number sense, geometry, and algebra domains. Participants completed lessons in mathematics classrooms and labs. Toward the end of the 2018 – 2019 school year, students completed the GMAS Mathematics assessment.

Descriptive statistics were conducted to describe and summarize the number of completed i-Ready lessons and GMAS Mathematics scale scores. For the variables, the researcher reported the mean (*M*), range, and standard deviation (*SD*). The GMAS Mathematics scale scores had a mean of 488.06 with a standard deviation of 31.36. The scores ranged from 406 to 572.

A bivariate correlation (i.e., Pearson *r*) was conducted to analyze the relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores. A moderate and negative relationship existed between the number of completed i-Ready lessons and GMAS Mathematics scale scores, $r(46) = -.39$. After analyzing the bivariate correlation, a scatter plot was used to display the data (Figure 4). The scatter plot also revealed a linear negative relationship, as the completed i-Ready lessons increased, the GMAS Mathematics scale scores decreased. Following the analysis of the bivariate correlation and the scatter plot, the researcher rejected the null hypothesis and concluded that there was a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

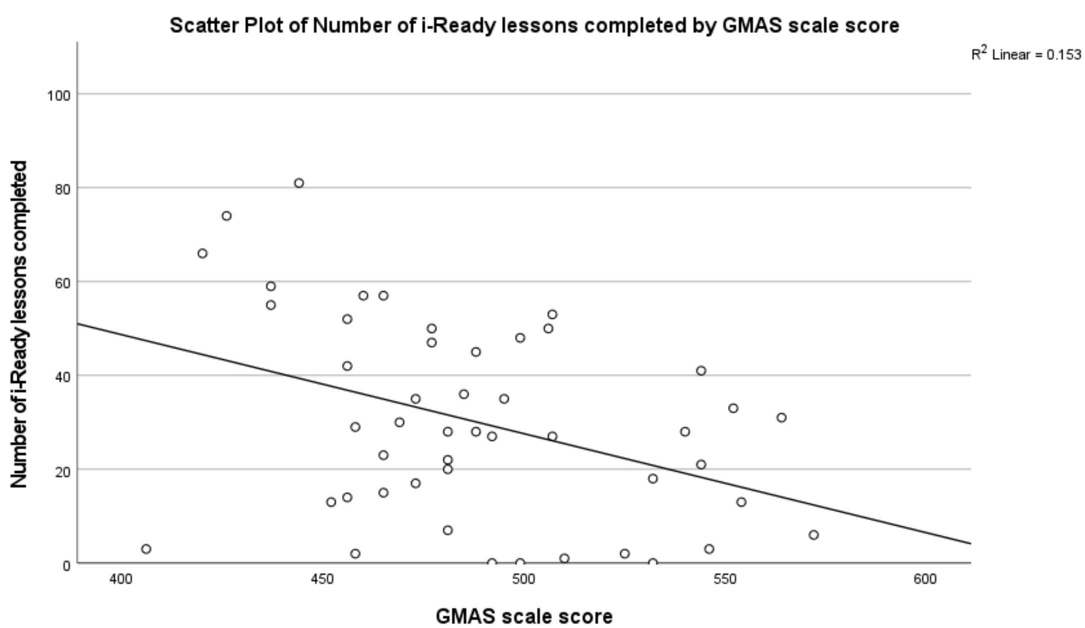

Figure 4. Scatter plot for number of completed i-Ready lessons and GMAS Mathematics scale scores.

Research Question 5: What are the average i-Ready gain scores for each GMAS Mathematics achievement level for eighth-grade students?

To answer Research Question 5, the researcher analyzed the descriptive statistics for the i-Ready gain scores (i.e., number sense, geometry, algebra) and the correlating GMAS Mathematics achievement levels. Below, in Table 14, the range, mean (*M*), and standard deviation (*SD*) for each GMAS Mathematics achievement level (i.e., beginning, developing, and proficient) were compared to number sense i-Ready gain scores. The total number of students with a beginning level score (*n* = 35) achieved low outcomes, *M* = -11.7, *SD* = 38.1, on the number sense gain scores. The participants' gain scores ranged from -108 to 61. Participants who scored at the developing level (*n* = 10) received moderate results, *M* = 28.8, *SD* = 36.6, on the number sense gain scores. The participants' gain scores ranged from -22 to 95. The participants who scored at the proficient level (*n* = 3) received higher results, *M* = 52, *SD* = 32.7, on the number sense gain scores. The participants' scores ranged from 24 to 88.

Table 14

Descriptive Statistics for Number Sense Gain Scores Compared to GMAS Mathematics Achievement levels

Achievement level	*N*	*Min*	*Max*	*M*	*SD*
Beginning	35	-108	61	-11.7	38.1
Developing	10	-22	95	28.8	35.6
Proficient	3	24	88	52	32.7

The researcher also addressed Research Question 5 by analyzing the range, mean, and standard deviation for GMAS Mathematics achievement levels compared to the geometry i-Ready gain scores (Table 15). The total number of students with a beginning level score (*n* = 35) achieved low geometry gain scores, *M* = -8.6, *SD* = 34.3. The participants' gain scores ranged from -116 to 78. Participants who scored at the developing level (*n* = 12) received adequate results, *M* = -6.1, *SD* = 47.8, on the geometry gain scores. The participants' gain scores ranged from -94 to 59. The participants who scored at the proficient level (*n* = 1) received higher results, *M* = 69. A range could not be calculated for the achievement level because only one participant achieved a proficient level.

Table 15

Descriptive Statistics for Geometry Gain Scores Compared to GMAS Mathematics Achievement levels

Achievement level	*N*	*Min*	*Max*	*M*	*SD*
Beginning	35	-116	78	-8.6	34.3
Developing	12	-94	59	-6.1	47.8
Proficient	1	69	69	69	-

The researcher completed addressing Research Question 5 by analyzing the range, mean, and standard deviation for the GMAS Mathematics achievement levels compared to the algebra i-Ready gain score (Table 16). The total number of students with a beginning level score (*n* = 37) achieved low algebra gain scores, *M* = -10.6, *SD* = 39.3. The participants' gain scores ranged from -79 to 80. Participants who scored at the developing level (*n* = 7) received adequate results, *M* = -4.1, *SD* = 28, on the algebra gain scores. The participants' gain scores ranged from -40 to 36. The participants who scored at the proficient level (*n* = 4) received higher results, *M* = 25.3, *SD* = 47.1, on the algebra gain scores. The participants' gain scores ranged from -32 to 80.

Table 16

Descriptive Statistics for Algebra Gain Scores Compared to GMAS Mathematics Achievement levels

Achievement level	*N*	*Min*	*Max*	*M*	*SD*
Beginning	37	-79	80	-10.6	39.3
Developing	7	-40	36	4.1	28
Proficient	4	-32	80	25.3	47.1

Research Question 6: What are middle school mathematics teachers' perceptions of implementing the i-Ready intervention program?

To address Research Question 6, the researcher conducted individual interviews with two teachers and utilized inductive coding to analyze phrases and create themes. The researcher read the transcribed data four times, line-by-line, to understand how each teacher participant perceived the implementation of the i-Ready intervention program. During the fifth reading, the researcher made notes in the margins and underlined phrases. The researcher identified themes within the transcriptions by hand coding the data. The themes created by the researcher were teacher needs, student needs, and positive and negative perceptions. From the themes, six subthemes were created for teacher needs (i.e., establish classroom expectations, monitor program use, parental involvement, support, training, and time to implement), three subthemes were created for student needs (i.e., growth, purposeful learning, and student's self-efficacy), two subthemes were created for positive perceptions (i.e., help kids and good/beneficial program), and three subthemes were created for negative perceptions (i.e., students not working, time training was provided, and learned without training).

One theme used to represent teachers' perceptions of implementing the i-Ready intervention program was teacher needs. Teacher A stated that teachers needed "training prior" to the use of the i-Ready program in the classroom. Teacher B acknowledged that "a set criterion" should be established to place students in the i-Ready exploratory classroom. When a criterion was not set, the participants perceived that the school was attempting to "meet the masses" by placing students in the class without supporting data. Teacher B stated, "Tier II or Tier III" received the intervention but "don't know the true set criteria". The second theme used to represent teachers' perceptions was student needs (i.e., growth, purposeful learning, and student's self-efficacy). Teacher A recognized that students benefited by completing the "i-Ready program daily", and Teacher B stated that the program "increased their level of performance in math". Teacher B also recognized that students needed to "take responsibility" and have a desire to decrease mathematical difficulties. The third and fourth themes were teachers' positive and negative perceptions. Teacher participants expressed positive perceptions (i.e., help kids and good/beneficial program) when describing the program but expressed negative perceptions (i.e., students not working, time training was provided, and learned without training) on how the i-Ready intervention program was implemented. The participants described the program as "beneficial" for improving student learning. Teacher A expressed that the program was beneficial when teachers implemented the program effectively and when students completed problems within the program on a daily basis. Although the participants expressed benefits with the program, Teacher A had to "feel my way through the program" without training. Teacher B had to learn how to implement the program "on my own", and the school provided a "quick hit and miss" training.

After the themes were created, the researcher read the transcript again and used descriptive codes to create subthemes (Table 17). The subthemes were utilized by the researcher to categorize the phrases. The researcher used the subthemes to explore how the participants perceived the implementation of the i-Ready intervention program. After the researcher organized the subthemes with the coinciding themes, the number of occurrences were calculated. Once the occurrences were calculated, the researcher determined the percentage for the themes and subthemes. The percentages were calculated by dividing the number of occurrences by the total number of occurrences (N = 147).

Table 17

Themes, subthemes, totals, percentages, and quotes from interviews

Themes and Subthemes	Total/Percentage (N = 147)	Participants' Quotes	Page Number/ Line Number
Teacher needs	85 (58%)	"The teacher did not set any expectations"	3/25
Establish classroom expectations	12 (8%)	"I believe the contributing factors will be parental support and teacher support"	3/41
Monitor program use	9 (6%)		
Parental involvement	7 (5%)	"Make sure parents really understand your child is in here because they've lost some skills, major skills along the way"	2/26
Support	14 (10%)		
Training	10 (7%)		
Time to implement	33 (22%)	"Don't give them training, and set them free"	2/11
Student needs	25 (17%)	"They need to take responsibility to want to be motivated to do better"	3/42
Growth	13 (9%)		
Purposeful learning	4 (3%)	"Weekly goals"	1/22
Student's self-efficacy	8 (5%)	"Actively engaged in their academics, because they can't grow, if they're not working"	3/41

Themes and Subthemes	Total/Percentage (N = 147)	Participants' Quotes	Page Number/ Line Number
Positive Perceptions	10 (7%)	"Majority of the kids work"	2/35
Help kids	4 (3%)	"They really want to grow and increase their level of performance in math"	3/13
Good/beneficial program	6 (4%)		
		"Not just a waste of time"	3/15
		"Beneficial for them everyday"	3/11
Negative Perceptions	27 (18%)	"You can't show growth, if you are not working"	1/31
Students not working	12 (8%)	"I had to feel my way through the program"	1/39
Time training was provided	8 (5%)	"Training prior to the first day of school or prior to the first day of use of program"	2/7
Learned without training	7 (5%)		

Based on the results in Table 17, themes, subthemes, totals, percentages, and quotes were used to display the quantity of the themes displayed by the participants. The researcher identified that the participants' perceived teacher needs (58%) were important for implementing the i-Ready intervention program. From the analyzed data, teacher needs were separated into six subthemes, which included classroom expectations (8%), monitor program use (6%), parental involvement (5%), administrative support (10%), training (7%), and time to implement (22%) the i-Ready intervention program. Following teacher needs, the participants developed negative perceptions (18%) toward implementing the i-Ready program. When implementing the program, students were not working (8%), timely training was not provided (5%), and teachers learned how to implement the program without training (5%). Although participants expressed negative perceptions of implementing the program, participants identified reasons why students needed the program (17%) and acknowledged positive perceptions for implementing the program. The teacher participants acknowledged that the program was beneficial (4%) and helped students (3%) learn the mathematical content. To improve mathematical knowledge, students needed to show growth (9%), meaningful assignments were needed for students to complete (3%), and students would need to develop self-efficacy (5%).

Integration

The researcher integrated the mixed methods study by merging the results (Table 18). The researcher inputted the research questions and summarized the quantitative and qualitative results in a joint display. The quantitative results revealed that the researcher did not reject the null hypothesis for Research Question 2. When the participants' gain scores for geometry were compared to the number of completed i-Ready lessons, the researcher failed to reject the null hypotheses and concluded that a relationship did not exist for eighth-grade students. For Research Questions 1, 3, and 4, the researcher rejected the null hypothesis and accepted the alternative hypothesis. When the participants' i-Ready gain scores for algebra and number sense were compared to the number of completed lessons, the researcher concluded that the relationship was weak for eighth-grade students. The relationship between number of completed i-Ready lessons and GMAS Mathematics scale scores was moderate and negative. The researcher identified themes that corresponded to students not achieving significant gain scores. For Research Question 5, the researcher analyzed descriptive statistics of the i-Ready gain scores and the corresponding GMAS Mathematics achievement levels. The descriptive statistics presented low, moderate, and high average gain scores for each GMAS Mathematics achievement level. The researcher identified the qualitative codes and themes that caused students to achieve low gain scores. For Research Question 6, the researcher analyzed the coded themes and phrases. With the qualitative data, the researcher determined that teachers developed a negative perceptions regarding how the i-Ready intervention program was implemented. From the analyzed quantitative and qualitative data, the results indicated how teachers perceived the implementation of the i-Ready intervention program. The qualitative results also provided evidence as to why students' gain scores did not produce a significant difference when the researcher analyzed the quantitative data. An integrated statement was constructed for each theme (i.e., Teacher Needs, Student Needs, and Possibilities) to merge the findings, and those statements are presented in Table 18.

Table 18

Integrated Themes

Themes	Research Question	Quantitative Results	Qualitative Results	Integrated Statement
Teacher Needs	What is the relationship between the number of completed i-Ready lessons and numbers sense i-Ready gain scores for eighth-grade students? What is the relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students?	A weak and negative relationship existed between the number of completed i-Ready lessons and number sense i-Ready gain scores, $r(46) = -.183$. No relationship existed between the number of completed i-Ready lessons and geometry i-Ready gain scores, $r(46) = .059$.	Support (10%); Training (7%); Time to implement (22%)	Teachers' perceptions of support, training, and time for implementing the i-Ready intervention program were ineffective for improving student achievement.

Themes	Research Question	Quantitative Results	Qualitative Results	Integrated Statement
	What is the relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students?	A weak and positive relationship existed between the number of completed i-Ready lessons and algebra i-Ready gain scores, *r*(46) = .190.		
Student Needs	What is the relationship between the number of i-Ready lessons completed and GMAS Mathematics scale scores for eighth-grade students?	A moderate and negative relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores, *r*(46) = -.39.	Purposeful learning (3%)	Teachers perceived that students needed purposeful learning from the i-Ready intervention program.
	What are the average i-Ready gain score for each GMAS Mathematics achievement level for eighth-grade students?	The mean gain scores for beginning level students indicated a lack of growth from pretest to posttest.	Growth (9%); Student's self-efficacy (5%)	Teachers perceived that students were not completing i-Ready lessons, which resulted in low growth and mathematical achievement.
Possibilities	What are middle school mathematics teachers' perceptions of implementing the i-Ready intervention program?	The gain scores for developing and proficient students tended to indicate growth from pretest to posttest.	Help kids (3%); good/beneficial program (4%); Teachers needed time to implement the program (22%); Teachers did not receive the training prior to implementation (5%)	Teachers perceived that the program could be beneficial to student learning in the areas of algebra, number sense, and geometry if adequate time and training were provided.

Summary

The purpose of the study was to examine the relationship between the i-Ready intervention program and students' mathematical achievement and to explore teachers' perceptions of implementing the i-Ready intervention program for eighth-grade students using an explanatory sequential mixed methods research design. From the quantitative data, the researcher conducted descriptive statistics, bivariate correlations, and scatter plots. After examining the quantitative data, the researcher concluded a moderate and negative relationship existed between the number of completed i-Ready lessons and GMAS Mathematics scale scores. With the qualitative data, the researcher categorized the coded subthemes into four themes, teacher needs, student needs, positive perceptions, and negative perceptions. The researcher explored how teachers developed a negative perception regarding how the i-Ready intervention program was implemented. The teachers perceived that adequate training was needed to implement the i-Ready intervention program effectively. In Chapter V, the researcher will analyze the findings, provide recommendations for future studies, identify limitations and implications of the study, and connect the findings with the literature presented in Chapter II.

CHAPTER V

DISCUSSION

Summary of the Study

This mixed methods research study addressed the relationship between the computer-managed instruction, i-Ready, and mathematical achievement as measured by i-Ready diagnostic data and GMAS Mathematics data. "Students' low achievement in mathematics is a matter of national concern" (Gersten et al., 2009, p. 4). In 2008, the National Mathematics Advisory Panel Report summarized the deficient mathematical performance on the Trends in International Mathematics and Science Study and the Program for International Student Assessment (Gersten et al., 2009). In the report, algebra teachers were surveyed, and key weaknesses were discovered among the students who were enrolled in algebra courses. A problem exists with using educational software as a mathematics intervention for middle grades students. To ensure students were receiving sufficient mathematical instruction, mathematics intervention programs remain important and common in primary, intermediate, and some secondary schools (Hines, 2016). Given the lack of experimental evidence, a gap in knowledge exists between the association between a computer-managed instruction (i.e., i-Ready) and Grade 8 mathematical achievement.

Quantitative data were collected from the i-Ready intervention program and GMAS assessment and analyzed with the SPSS software. The qualitative interviews were transcribed, hand coded, and analyzed. The data were integrated and presented in tables. The participants included 48 eighth-grade students and two eighth-grade teachers. Of the

48 participants, 31 were identified as receiving Tier II intervention, and 17 were identified as receiving Tier III intervention services.

1. What is the relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students?

   H_{o1} There is not a relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students.

   H_{a1}: There is a relationship between the number of completed i-Ready lessons and number sense i-Ready gain scores for eighth-grade students.

2. What is the relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students?

   H_{o2}: There is not a relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

   H_{a2}: There is a relationship between the number of completed i-Ready lessons and geometry i-Ready gain scores for eighth-grade students.

3. What is the relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students?

   H_{o3}: There is not a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

   H_{a3}: There is a relationship between the number of completed i-Ready lessons and algebra i-Ready gain scores for eighth-grade students.

4. What is the relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students?

H_o4: There is not a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

H_a4: There is a relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores for eighth-grade students.

5. What are the average i-Ready gain scores for each GMAS Mathematics achievement level for eighth-grade students?
6. What are middle school mathematics teachers' perceptions of implementing the i-Ready intervention program?

This study combined quantitative and qualitative data to answer research questions related to the effectiveness of a program to improve student achievement. To answer Research Questions 1, 2, 3, 4, and 5, quantitative data were analyzed, and qualitative data were analyzed for Research Question 6. The variables in the study were the number of completed i-Ready lessons, i-Ready gain scores (i.e., algebra, geometry, and number sense), GMAS Mathematics scale scores, and GMAS Mathematics achievement levels (i.e., beginning, developing, proficient). For the qualitative phase, teachers' perceptions were explored to obtain an in-depth description of perceptions regarding the implementation of the i-Ready intervention program.

Analysis of the Findings

Quantitative

Oliver and Herrington (2003) stated that the components of the e-learning framework are resources (i.e., people), support (i.e., technologies), and activities (i.e., services). For the current study, teachers and students were the resources, student support was provided through the i-Ready intervention program, and teacher support was provided by administrators and i-Ready specialists. In the study, quantitative data were analyzed using a series of bivariate correlations to examine the relationship between the number of completed i-Ready lessons, i-Ready gain scores (i.e., number sense, geometry, and algebra), GMAS Mathematics scale scores, and GMAS Mathematics achievement levels (i.e., beginning, developing, and proficient).

For Research Question 1, the bivariate correlation revealed a weak and negative relationship existed between the number of completed i-Ready lessons and number sense gain scores. The researcher rejected the null hypothesis and accepted the alternative hypothesis. Similar to the current study, Earle and Fraser's (2017) mixed methods study analyzed students' data from a computer-based program. After analyzing the data, the researchers discovered that the program did not produce statistically significant effects on student achievement. In contrast, Butterworth and Laurillard (2010) conducted a mixed methods study and discovered that student achievement increased after utilizing a mathematical program.

For Research Question 2, the bivariate correlation did not reveal a relationship between the number of completed i-Ready lessons and the geometry gain scores, and the researcher failed to reject the null hypothesis. Like the current study, Chappell et al. (2015), Kelly and Rutherford (2017), Gilmore (2018), and Morales (2016) conducted research with a computer-based program. From the results of the studies, the online tutorial program and the intervention software did not produce significant effects on student achievement. In contrast, Camilleri and Camilleri (2017) and Vate-U-Lan (2017) studies utilized the e-learning theory, and student achievement increased. In these studies, participants' problem-solving and critical thinking skills improved. Similar to these studies, student participants' problem-solving and critical thinking skills improved in algebra. Cahyono and Waluyo (2019) acknowledged that critical thinking skills were needed to solve algebraic problems.

For Research Question 3, the bivariate correlation revealed a relationship between the number of completed i-Ready lessons and algebra gain scores, and the researcher rejected the null hypothesis and accepted the alternative hypothesis. Ziegler and Stern (2016) and Fay (2017) also found algebraic achievement was impacted after utilizing a computer-based program. From the results of Fay's (2017) qualitative study, participants perceived that student learning had accelerated with computer-based instruction after the schools implemented operational and cultural factors. Ziegler and Stern (2016) conducted a quantitative study and found a statistically significant difference in students' knowledge after using a computer-based program to learn algebra.

For Research Question 4, the bivariate correlation revealed a moderate and relationship between the number of completed i-Ready lessons and GMAS Mathematics scale scores. The researcher rejected the null hypothesis and accepted the alternative hypothesis. In a study conducted by Kiili et al. (2015), student achievement increased after utilizing a computer-based program. From the results of the quantitative study, participants' conceptual knowledge and understanding of rational numbers improved. In contrast, Mahmoudi et al. (2015) conducted a study with a computer-based program, and student achievement did not improve. Results from the statistical data revealed that the program did not produce statistically significant effects on student achievement.

For Research Question 5, descriptive statistics of the i-Ready gain scores and the correlating GMAS Mathematics achievement levels were analyzed. From the analyzed data, the researcher determined the areas where students received low, moderate, and high gain scores. For the beginning level, more participants achieved gain scores at this level for the number sense domain ($n = 37$). At the developing level, more participants achieved scores at this level for the geometry domain ($n = 12$), and more participants scored at the proficient level for the number sense domain ($n = 4$). The analyses indicated that the number of completed i-Ready lessons and gain scores had large variation. Related to the current study, Hannafin and Foshay (2008) conducted a study and analyzed gain scores. From the results of the study, student achievement increased significantly from Grade 8 to Grade 10. In the current study, as students completed i-Ready lessons, algebra gain score also increased. After analyzing the GMAS Mathematics achievement levels, proficient learners, which was a small group, improved by an average of 25.3 points in algebra, 52 points in number sense, and 69 points in geometry.

Qualitative

For the qualitative component, for Research Question 6, the researcher used an intrinsic case study to analyze the data by transcribing, coding, and analyzing the data. The qualitative data were organized into four themes, which included teacher needs, student needs, positive perceptions, and negative perceptions. One key qualitative finding was that teachers developed negative perceptions regarding how the i-Ready intervention program was implemented because of inadequate training, lack of support, and not having enough time to implement the program. Similar to the current study, teachers in Kelly and Rutherford's (2017) study did not implement the intervention program effectively, and student achievement was impacted negatively. Kelly and Rutherford stated that the intervention classrooms lacked structure and teachers did not assign lessons that the students needed to improve student achievement. Another key finding from the current study was the teachers developed positive perceptions regarding the i-Ready intervention program because the program was beneficial for some eighth-grade students. Wee et al. (2012), Katmada et al. (2014), and Pritami and Muhimmah (2018) also conducted studies with computer-managed instruction that produced learning opportunities, which were helpful for students to learn. The current findings indicated that teachers had positive and negative perceptions on the implementation of the i-Ready intervention program, and a relationship existed between some of the research variables.

Integration

To integrate the findings, the results were merged in a joint display. In the display, the research questions were organized by the coded themes. For Research Questions 1, 2, and 3, “teacher needs” was the theme that coincided with the findings. From the quantitative findings, no relationship to weak relationships existed between the number of completed lessons and the i-Ready gain scores. From the qualitative findings, participants perceived that ongoing support, training on the program, and time to implement the program were needed to improve student achievement. In a study, Rochelle et al. (2016) found that teachers received professional development, ongoing training, and assistance from the academic coaches throughout the school year to implement the ASSISTments program. At the conclusion of the study, students who received interventions from the trained teachers achieved statistically significant higher scores than the control group participants. In Earle and Fraser’s (2017) study, teacher support was statistically significant when students used technology to learn mathematics.

Findings from the survey data indicated that students developed negative perceptions using computer games to learn mathematics when teacher support was not evident.

For Research Questions 4 and 5, “student needs” was the theme linked to the findings. From the quantitative findings, beginning level gain scores were low, along with the geometry gain scores for the developing level. Although the geometry gain scores were low, the GMAS Mathematics scale scores were low, and the developing level learners demonstrated improved knowledge. From the qualitative findings, participants perceived that growth, purposeful learning, and self-efficacy were needed to improve student achievement. For Research Question 6, “possibilities” was the theme associated with the findings. From the qualitative findings, participants perceived that the i-Ready intervention program provided benefits and challenges for student achievement. Participants recognized that the program helped students, but teachers needed time and training to implement the program effectively. Hall (2019) stated that, when teachers received effective training, student learning would be maximized by the educational program.

Limitations of the Study

The current study contained limitations in external and internal validity. A limitation to external validity was the inability to generalize the research findings. The limitation was created when the study utilized only one rural school district and participants were not selected randomly (Johnson & Christensen, 2019). The teacher and student participants were chosen by purposive sampling with a specific criterion. Another limitation to generalizability was a small sample size. The small number of participants increased the sampling error and did not represent the population of the school (Johnson

& Christensen). Research findings were limited to other settings, participants, and geographical locations. Internal validity was created with testing, regression artifact, maturation, and history of gathering and analyzing the data (Johnson & Christensen, 2019). Testing limitations existed because participants completed the same assessment, i-Ready, for the pretest and posttest administrations. Another testing limitation was the type of tests that were analyzed. The i-Ready assessment was an adaptive assessment, and the GMAS was a standardized assessment. The i-Ready assessment adapted to the students' knowledge learned from the completed lessons, and the GMAS measured the knowledge that students gained from the standards-based classroom. Another threat to internal validity was regression artifacts. The student participants who received Tier II and III mathematical interventions could have scored the lowest scores on the pretest. When these participants were used in the study, regression to the mean could cause a change in test scores, which might not be related to the treatment condition. The next threat to internal validity was maturation. After the pretest was administered, participants completed i-Ready lessons (i.e., intervention) before completing the posttest. The change in students' knowledge could be due to content that was taught from the teacher or from the intervention. The final threat to internal validity was the history of time between analyzing the quantitative data and qualitative data. The quantitative and qualitative data were gathered and analyzed after participants completed the school year. The teacher participants in this study continued to utilize the i-Ready intervention program and to provide the intervention to Tier II and III students after the 2018-2019 school year.

Recommendations for Future Research

Based on the findings of the current study, the researcher recommended options for future research. First, future research could include more school districts to increase generalizability. Studies could utilize random sampling to select participants and interview more teachers using focus groups. Johnson and Christensen (2019) stated that the recommended size of focus groups was 6 to 12 participants. Future research studies could use racial classification and gender as covariates to determine how computer-based programs impacted student achievement. Studies conducted by Halpern et al. (2007) and Ullman et al. (2008) revealed that gender impacted students' learning with movement tasks and oral competency tests. Future studies could determine how timely professional learning and support would impact teachers' perceptions on implementing the program. Finally, future studies could utilize longitudinal research to analyze and gather data from two consecutive school years. Johnson and Christensen (2019) identified this research as collecting data at more than one period to make associations across time.

Implications of the Study

After analyzing the findings, implications were produced from the study. First, adequate training on the i-Ready intervention program could improve teachers' perceptions of implementing the program. Initial training could be provided before teachers implement the i-Ready intervention program. A representative from the company could inform teachers how to assign additional lessons, monitor student progress, and understand the data from the program. Additionally, teachers could receive ongoing training and support throughout the school year from instructional coaches. The instructional coaches and teachers could ensure that students are completing the interventions by analyzing the i-Ready data weekly. Another implication was that students' mathematical achievement could improve if the i-Ready program were implemented effectively.

Conclusion

Chapter V presented a summary of the study and an analysis of the quantitative, qualitative, and integrated findings, limitations, implications, and recommendations for future research. The current research reviewed studies with educational programs, interviewed participants, and gathered and analyzed data. The research from this study examined the relationship between the i-Ready intervention program and Grade 8 mathematical achievement. After the completion of the study, the findings will be presented to the superintendent of the school to inform the school leader of teachers' perceptions and the quantitative findings. Based on the findings, timely professional learning and ongoing support were perceived by teachers to improve teachers' perceptions and students' mathematical knowledge. Subsequently, the school leaders could create an action plan to improve student achievement with the i-Ready intervention program. In the plan, the school leaders could address how and when teachers will receive professional learning and ongoing support to implement the intervention effectively. In addition, the plan could identify when students would be required to complete lessons within the program, could identify how often student progress would be reported to administrators, and could create next steps for students who are not showing progress with the program. If effective professional learning and ongoing support could be provided to teachers, then mathematical achievement for eighth-grade students could be increased.

REFERENCES

Akcaoglu, M., Gutierrez, A. P., Hodges, C. B., & Sonnleitner, P. (2017). Game design as a complex problem-solving process. In *Handbook of research on serious games for educational applications* (pp. 217-233). IGI Global, Hershey, PA.

Akkus, M. (2016). The common core state standards for mathematics. *International Journal of Research in Education and Science*, *2*(1), 49-54.

Akoglu, H. (2018). User's guide to correlation coefficients. *Turkish Journal of Emergency Medicine*, *18*(3), 91-93. https://doi.org/10.1016/j.tjem.2018.08.001

Alrabai, F. (2016). Factors underlying low achievement of Saudi EFL learners. *International Journal of English Linguistics*, *6*(3), 21-37.

Altun, T., & Bektaş, E. (2010) Views of Regional Boarding School teachers about the use of ICT in education. *Procedia Social and Behavioral Sciences, 9,* 462–467.

American Psychological Association. (2010). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: Author.

Aparicio, M., Bacao, F., & Oliveira, T. (2016). An e-learning theoretical framework. *An e-Learning Theoretical Framework*, (1), 292-307.

Asempapa, R. (2017). How did we get here? The path to our current K-12 mathematics education curriculum in the United States. *Association for University Regional Campuses of Ohio*, *23*, 1-10.

Atkins, D. E., Brown, J. S., & Hammond, A. L. (2007). *A review of the open educational resources (OER) movement: Achievements, challenges, and new opportunities*, 164. Mountain View, CA: Creative Common.

Ayan, R., & Isiksal-Bostan, M. (2019). Middle school students' proportional reasoning in real life contexts in the domain of geometry and measurement. *International Journal of Mathematical Education in Science and Technology*, *50*(1), 65-81.

Bahrani, T. (2011). Computer assisted language learning-Some aspects. *Language in India, 11*(9), 271-278.

Bellibas, M. S. (2016). Who are the most disadvantaged? Factors associated with the achievement of students with low socio-economic backgrounds. *Educational Sciences: Theory and Practice*, *16*(2), 691-710.

Bhalla, J. (2013). Computer use by school teachers in teaching-learning process. *Journal of Education and Training Studies*, *1*(2), 174-185.

Banda, D. R., Dogoe, M. S., & Matuszny, R. M. (2011). Review of video prompting studies with persons with developmental disabilities. *Education and Training in Autism and Developmental Disabilities*, *46*, 514–527.

Banister, S. (2010). Integrating the iPod touch in K–12 education: Visions and vices. *Computers in the Schools, 27*(2), 121–131. doi: 10.1080/07380561003801590

Barnett, E., Fay, M., Pheatt, L., & Trimble, M. (2016). *What we know about transition courses.* New York, NY: Columbia University, Teachers College, Community College Research Center.

Bartell, T. G., Bieda, K. N., Putnam, R. T., Bradfield, K., & Dominguez, H. (Eds.). (2015). *Proceedings of the 37th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* East Lansing: Michigan State University.

Bazeley, P. (2009). Editorial: Integrating data analyses in mixed methods research. *Journal of Mixed Methods Research, 3*(3), 203.

Becker, J. P., & Jacob, B. (2000). The politics of California school mathematics: The anti-reform of 1997-99. *Phi Delta Kappan, 81*(7), 529-532, 534-537.

Bellini, S., & Akullian, J. (2007). A meta-analysis of video modeling and video self-modeling interventions for children and adolescents with ASD. *Exceptional Children*, *73*, 261–328.

Berggren, S., Fletcher-Watson, S., Milenkovic, N., Marschik, P. B., Bölte, S., & Jonsson, U. (2018). Emotion recognition training in autism spectrum disorder: A systematic review of challenges related to generalizability. *Developmental Neurorehabilitation*, *21*(3), 141-154.

Bickerstaff, S., Fay, M. P., & Trimble, M. J. (2016). *Modularization in developmental mathematics in two states: Implementation and early outcomes*. New York, NY: Community College Research Center, Teachers College, Columbia University. Retrieved from https:// ccrc.tc.columbia.edu/media/k2/attachments/modularization-developmental-mathematicstwo-states.pdf

Bippert, K., & Harmon, J. (2017). Middle school teachers' perceptions of computer-assisted reading intervention programs. *Reading Psychology*, *38*(2), 203-230.

Black, S. (2014). *Implementation of the No Child Left Behind Act: Evaluating the effects on student achievement* (Order No. 3630812). Available from ProQuest Dissertations & Theses A&I. (1564232689)

Bogdan, R. C., & Biklen, S. K. (2016). *Qualitative research for education: An introduction to theories and methods* (5th ed.). Uttar Pradesh, India: Pearson.

Bouck, E. C., & Cosby, M. D. (2017). Tier 2 response to intervention in secondary mathematics education. *Preventing School Failure: Alternative Education for Children and Youth*, *61*(3), 239-247.

Bourque, M. L. (2009). *A history of NAEP achievement levels: Issues, implementation, and impact 1989-2009*. Washington, DC: National Assessment Governing Board.

Bradley, R., Danielson, L., & Doolittle, J. (2005). Response to intervention. *Journal of Learning Disabilities,* 485-486. doi: 10.1177/00222194050380060201

Brayshaw, M., & Gordon, N. (2016). Using motivation derived from computer gaming in the context of computer-based instruction. In *2016 SAI computing conference (SAI)* (pp. 828-832). New York, NY: Institute of Electrical and Electronics Engineers Publishing.

Brewer, J., & Hunter, A. (1989). *Multimethod research: A synthesis of styles.* Newbury Park, CA: SAGE Publications.

Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done? *Qualitative Inquiry, 6*(1), 97-113.

Bunch, M. B. (2017). Test review of i-Ready K-12 diagnostic and K-8 instruction. In J. F. Carlson, K. F. Geisinger, & J. L. Jonson (Eds.), *The twentieth mental measurements yearbook.* Retrieved from http://marketplace.unl.edu/buros/

Burbules, N. C., & Callister, T. A., Jr. (2000). *Watch IT: The risks and promises of information technologies for education.* Boulder, CO: Westview.

Burns, M. K., Kanive, R., & DeGrande, M. (2012). Effect of a computer-delivered math fact intervention as a supplemental intervention for math in third and fourth grades. *Remedial and Special Education, 33*(3), 184–191.

Burrill, G. (2001). Mathematics education: The future and the past create a context for today's issues. In T. Loveless (Ed.), *The great curriculum debate: How should we teach reading and math?* (pp. 25–41). Washington, DC: Brookings Institution Press.

Butterworth, B., & Laurillard, D. (2010). Low numeracy and dyscalculia: Identification and intervention. ZDM *Mathematics and Education, 42*(6), 527–539.

Cabus, S. J. (2015). Does enhanced student commitment reduce school dropout? Evidence from two major dropout regions in the Netherlands. *Regional Studies, 49*(4), 599-614. doi: 10.1080/00343404.2013.799760

Cahyono, B., & Waluyo, B. (2019). Analysis critical thinking skills in solving problems algebra in terms of cognitive style and gender. *Journal of Physics: Conference Series*, *1321*(2), 022115. doi:10.1088/1742-6596/1321/2/022115

Cai, S., Chiang, F.-K., & Wang, X. (2013). Using the augmented reality 3D technique for a convex imaging experiment in a physics course. *International Journal of Engineering Education, 29(4)*, 856–865.

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of augmented reality simulation system application in a chemistry course. *Computers in Human Behavior, 37,* 31–40. doi:10.1016/j.chb.2014.04.018

Cai, S., Chiang, F. K., Sun, Y., Lin, C., & Lee, J. J. (2017). Applications of augmented reality-based natural interactive learning in magnetic field instruction. *Interactive Learning Environments*, *25*(6), 778-791.

Callaghan, M. N., Long, J. J., Van Es, E. A., Reich, S. M., & Rutherford, T. (2018). How teachers integrate a math computer game: Professional development use, teaching practices, and student achievement. *Journal of Computer Assisted Learning*, *34*(1), 10-19.

Camilleri, M. A., & Camilleri, A. C. (2017). The students' perceptions of digital game-based learning. *European Conference on Games Based Learning*, *11*, 56 – 62.

Cannella-Malone, H., Fleming, C., Chung, Y.-C., Wheeler, G., Basbagill, A., & Singh, A. (2011). Teaching daily living skills to seven individuals with severe intellectual disabilities: A comparison of video prompting to video modeling. *Journal of Positive Behavior Interventions*, *13*, 144–153.

Caracelli, V. J., & Greene, J. C. (1997). Crafting mixed-method evaluation designs. In J. C. Greene & V. J. Caracelli (Eds.), *Advances in mixed-method evaluation: The challenges and benefits of integrating diverse paradigms* (pp. 19-32). San Francisco, CA: Jossey-Bass.

Carr, J. (2012). Does math achievement h’APP’en when iPads and game-based learning are incorporated into fifth-grade mathematics instruction? *Journal of Information Technology Education Research*, *11*(1), 269-286.

Carroll, J. M., & Swatman, P. A. (2000). Structured-case: A methodological framework for building theory in information systems research. *European Journal of Information Systems, 9*(4), 235–242.

Castro, F. G., Kellison, J. G., Boyd, S. J., & Kopak, A. (2010). A methodology for conducting integrative mixed methods research and data analyses. *Journal of Mixed Methods Research*, *4*(4), 342-360.

Çelik, A., Erduran, A., & Eryiğit, P. (2017). The effect of utilizing the three-dimensional dynamic geometry software in geometry. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi*, *41*, 1-16.

Center for Community College Student Engagement. (2016). *Expectations meet reality: The underprepared student and community colleges.* Austin: The University of Texas at Austin, College of Education, Department of Educational Administration, Program in Higher Education Leadership.

Chafin, A. F., Green, R. B., Raiford, S. A., Hsiao, E. L., Nobles, K. D., & Truby, W. F. (2015). Using mathematics curriculum-based measurement to predict student performance on the third grade Georgia Mathematics Criterion Referenced Competency Test. *National Teacher Education Journal*, *8*(2), 27-37.

Chang, H. Y., Wu, H. K., & Hsu, Y. S. (2013). Integrating a mobile augmented reality activity to contextualize student learning of a socioscientific issue. *British Journal of Educational Technology, 44(3)*, E95–E99.

Chappell, S., Arnold, P., Nunnery, J., & Grant, M. (2015). An examination of an online tutoring program's impact on low-achieving middle school students' mathematics achievement. *Online Learning*, *19*(5), 37-53.

Chen, S. Y., & Macredie, R. (2010). Web-based interaction: A review of three important human factors. *International Journal of Information Management*, *30*(5), 379-387.

Cheung, A. C., & Slavin, R. E. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. *Educational Research Review*, *9*, 88-113.

Childs, R. A., & Jaciw, A. P. (2002). Matrix sampling of items in large-scale assessments. *Practical Assessment, Research, and Evaluation*, *8*(1), 16.

Chinn, P. C. (2004). Brown's far reaching impact. *Multicultural Perspectives*, *6*(4), 9-11.

Chu, H. C. (2014). Potential negative effects of mobile learning on students' learning achievement and cognitive load—A format assessment perspective. *Journal of Educational Technology & Society*, *17*(1), 332-344.

Cochrane, S., & Cuevas, J. A. (2015). Teacher perceptions of the common core performance standards. *Georgia Educational Researcher*, *12*(1), 1.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Cohen, L., Manion, L., & Morrison, K. (2013). *Research Methods in Education*. London, UK: Routledge.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York. R. L. (1966). *Equality of educational opportunity*. Washington, D.C.: U.S. Government Printing Office.

Colorado State University. (2011). *Types of questions.* Retrieved from http://writing.colostate.edu/guides/research/survey/com4a2a.cfm

Creamer, E. G. (2018). *An introduction to fully integrated mixed methods research.* Thousand Oaks, CA: SAGE Publications.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: SAGE Publications.

Creswell, J. W. (2013). Qualitative Inquiry and research design choosing among five approaches (3rd ed.). Thousand Oaks, CA: SAGE Publications.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Thousand Oaks, CA: SAGE Publications.

Creswell, J. W., Clark, V. L. P., Gutmann, M. L., & Hanson, W. E. (2007). An expanded typology for classifying mixed methods research into designs. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 159–196). Thousand Oaks, CA: SAGE Publications.

Creswell, J. W., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39,* 124–130.

Creswell, J. W., Klassen, A. C., Plano Clark, V. L., & Smith, K. C. (2011). Best practices for mixed methods research in the health sciences. *National Institutes of Health*, *2013*, 541-545.

Cronin, J., Dahlin, M., Adkins, D., & Kingsbury, G. G. (2007). *The proficiency illusion.* Washington, DC: Thomas B. Fordham Institute.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom.* Cambridge, MA: Harvard University Press.

Curriculum Associates (2015a). *i-Ready research base for instruction*. Retrieved from https://www.casamples.com/downloads/iReadyResearchBaseInstruction_final.pdf

Curriculum Associates (2015b). *i-Ready teacher training guide*. North Billerica, MA: Curriculum Associates, LLC.

Curriculum Associates. (2015c). *i-Ready diagnostic & instruction: User guide.* North Billerica, MA: Curriculum Associates, LLC. Retrieved from https://www.curriculumassociates.com/Products/i-Ready

Curriculum Associates (2016). *i-Ready adaptive diagnostic.* Retrieved from http://www.curriculumassociates.com/products/i-Ready/i-Ready-adaptivediagnostic-assessment.aspx

Curriculum Associates (2017). *The science behind i-Ready's adaptive diagnostic.* Retrieved from https://www.casamples.com/downloads/i-Ready_DiagnosticPositionPaper_090914.pdf

Cusumano, D. L., Algozzine, K., & Algozzine, B. (2014). Multi-tiered system of supports for effective inclusion in elementary schools. *Handbook of Effective Inclusive Schools: Research and Practice*, *1*, 197-209.

Dabbagh, N. (2005). Pedagogical models for e-learning: A theory-based design framework. *International Journal of Technology in Teaching and Learning, 1*(1), 25–44.

Damms, R. V. (2002). *The Eisenhower presidency, 1953-1961.* London, UK: Pearson Education Limited.

Day, R., & Payne, L. (1987). Computer managed instruction: An alternative teaching strategy. *Journal of Nursing Education, 26*(1), 30-36.

Delgado, A. J., Wardlow, L., McKnight, K., & O'Malley, K. (2015). Educational technology: A review of the integration, resources, and effectiveness of technology in K-12 classrooms. *Journal of Information Technology Education: Research, 14,* 397-416. Retrieved from http://www.jite.org/documents/Vol14/JITEv14ResearchP397-416Delgado1829.pdf

Dickson, P. (2004). Sputnik, blow to America. *The Globalist*. Retrieved from http://www.theglobalist.com/DBWeb/StoryId.aspx?StoryId=2218

Downing, J. E., & Gifford, V. (1996). An investigation of preservice teachers' science process skills and questioning strategies used during a demonstration science discovery lesson. *Journal of Elementary Science Education, 8*(1), 64–75.

Duhon, G. J., House, S. H., & Stinnett, T. A. (2012). Evaluating the generalization of math fact fluency gains across paper and computer performance modalities. *Journal of School Psychology, 50,* 335–345.

Earle, J. E., & Fraser, B. J. (2017). Evaluating online resources in terms of learning environment and student attitudes in middle-grade mathematics classes. *Learning Environments Research*, *20*(3), 339-364.

Educational Research Institute of America. (2018). *i-Ready diagnostic and Georgia Milestones linking study*. Bloomington, IN: Curriculum Associates, LLC.

Elam, S. M. (Ed.). (1964). *Education and the structure of knowledge*. Chicago, IL: Rand, McNally, and Company.

Ewe, U. C., Njoku, N. A., & Alio, A. N. (2017). Use of computer assisted instruction (CAI) in the teaching of basic electricity in technical colleges in Enugu State. *Journal of Research in Science and Technology Education*, *7*(2), 72 – 85.

Ezzelle, C. (2017). Test review of i-Ready K-12 diagnostic and K-8 instruction. In J. F. Carlson, K. F. Geisinger, & J. L. Jonson (Eds.), *The twentieth mental measurements yearbook*. Retrieved from http://marketplace.unl.edu/buros/

Fairlie, R. W. (2016). Do boys and girls use computers differently, and does it contribute to why boys do worse in school than girls?. *The BE Journal of Economic Analysis & Policy*, *16*(1), 59-96.

Fay, M. P. (2017). *Computer-mediated developmental math courses in Tennessee high schools and community colleges: An exploration of the consequences of institutional context* (Working Paper No. 91). New York, NY: Columbia University, Teachers College, Community College Research Center.

Ferrini-Mundy, J. (2000). Principles and standards for school mathematics: A guide for mathematicians. *Notices of the American Mathematical Society*, *47*(8).

Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs—principles and practices. *Health Services Research*, *48*(6), 2134-2156.

Fetters, M. D. & Freshwater, D. (2015). Publishing a methodological mixed methods research article. *Journal of Mixed Methods Research, 9*(3), 203–213.

Fey, J. T., & Graeber, A. O. (2003). From the new math to the agenda for action. *A History of School Mathematics*, *1*, 521-558.

Fischer, A. (2011). Gendered social interactions in face-to-face and computer-mediated communication. *Face-to-Face Communication over the Internet*, 53-78.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Thousand Oaks, CA: SAGE Publications.

Foroughi, A. (2015). The theory of connectivism: Can it explain and guide learning in the digital age? *Journal of Higher Education Theory and Practice*, *15*(5), 11.

Forte, E., Towles, E., Greninger, E., Buchanan, E., & Deters, L. (2017). *Evaluation of the alignment quality in the Georgia Milestones Assessment System in ELA, mathematics, science, and social studies, Executive summary.* Alexandria, VA: edCount. Retrieved from http://www.gadoe.org/Curriculum-Instructionand-Assessment/Assessment/Documents/Milestones/Georgia_ Milestones_Alignment_Evaluation_Executive_Summary.pdf

Foster, M. E., Anthony, J. L., Clements, D. H., Sarama, J., & Williams, J. M. (2016). Improving mathematics learning of kindergarten students through computer-assisted instruction. *Journal for Research in Mathematics Education*, *47*(3), 206-232.

Freeze, R. D., Alshare, K. A., Lane, P. L., & Wen, H. J. (2019). Is success model in e-learning context based on students' perceptions?. *Journal of Information Systems Education*, *21*(2), 4.

Fromme, M. (2018). Special education teachers' response to consistent changes in curriculum standards. *University Honors Program Theses*, 354. Retrieved from https://digitalcommons.georgiasouthern.edu/honors-theses/354

Fuchs, L. S., Fuchs, D., & Compton, D. L. (2010). Rethinking response to intervention at middle and high school. *School Psychology Review, 39*(1), 22–28.

Gardner, S., & Wolfe, P. (2013). Use of video modeling and video prompting interventions for teaching daily living skills to individuals with autism spectrum disorders: A review. *Research and Practice for Persons with Severe Disabilities*, *38*, 73–87. doi: 10.2511/027494813807714555

Garneli, V., Giannakos, M., & Chorianopoulos, K. (2017). Serious games as a malleable learning medium: The effects of narrative, gameplay, and making on students' performance and attitudes. *British Journal of Educational Technology*, *48*(3), 842-859.

Gatlin, J. (2009). *The perceptions of regular high school and dual enrollment teachers and dual enrollment students toward college preparedness and dual enrollment courses in two Tennessee public school systems*. (Doctoral dissertation, Tennessee State University). Retrieved from ProQuest Dissertations and Theses.

Georgia Department of Education. (2007). *Georgia Performance Standards (GPS) mathematics curriculum summary.* Retrieved from http://public.doe.k12.ga.us/DMGetDocument.aspx/GPS%20Math%20%20Summary.pdf?p=6CC6799F8C1371F65B8FCB5B20E49838543F4EB818396E1A52CEFBB76CC1B0&Type=D

Georgia Department of Education. (2010). *Georgia performance standards*. Retrieved from https://www.georgiastandards.org/Standards/Pages/BrowseStandards/BrowseGPS.aspx

Georgia Department of Education. (2016). *Georgia standards of excellence: Mathematics*. Atlanta, GA: Author. Retrieved from https://www.georgiastandards.org/GeorgiaStandards/Frameworks/Coordinate-Algebra-Standards.pdf

Georgia Department of Education. (2017). Georgia milestone 2016-2017 statewide scores. Retrieved from http://www.gadoe.org/Curriculum-Instruction-and-

Assessment/Assessment/Pages/Georgia-Milestones-2016-2017-Statewide-Scores.aspx

Georgia Department of Education (2018). *An assessment & accountability brief: 2017-2018 Georgia Milestones validity and reliability.* Atlanta, GA: Author. Retrieved 21 August 2020 from https://www.gadoe.org/Curriculum-Instruction-and-Assessment/Assessment/Documents/Milestones/2017-18_Georgia_Milestones_Validity_and_Reliability_Brief.pdf

Georgia Department of Education. (2019a). *Georgia Milestones: EOG resources*. Atlanta, GA: Author. Retrieved 20 June 2019 from https://www.gadoe.org/Curriculum-Instruction-and-Assessment/Assessment/Documents/Milestones/EOG-Resources/EOG_2019_Score_Interpretation_Guide.pdf

Georgia Department of Education (2019b). *An assessment & accountability brief: 2018-2019 Georgia Milestones validity and reliability.* Atlanta, GA: Author. Retrieved 21 August 2020 from https://www.gadoe.org/Curriculum-Instruction-and-Assessment/Assessment/Documents/Milestones/2018-19_Georgia_Milestones_Validity_and_Reliability_Brief.pdf#search=validity%20 2018

Georgia Department of Education. (n.d.). *Mathematics curriculum revision executive summary.* Retrieved from http://public.doe.k12.ga.us/DMGetDocument.aspx/gps_summary_math.pdf?p=4BE1EECF99CD364EA5554055463F1FBBF5D074D5FB1F2CAEB3B63B3ECB220CDD26C2114F3C57D8D2925C2E80687C2A69&Type=D

Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J. R., & Witzel, B. (2009). *Assisting students struggling with mathematics: Response to intervention (RtI) for elementary and middle schools* (NCEE 2009-4060). Washington, DC: National Center for Education Evaluation and Regional Assistance.

Gifford, S. (2004). A new mathematics pedagogy for the early years: In search of principles for practice. *International Journal of Early Years Education*, *12*(2), 99-115.

Gilmore, K. (2018). *The impact of computer-based programs on middle school math achievement* (Order No. 10811137). Available from ProQuest Dissertations & Theses A&I. (2050816464).

Goodyear, P., & Retalis, S. (2010). *Technology-enhanced learning*. Rotterdam, The Netherlands: Sense Publishers.

Govindasamy, T. (2001). Successful implementation of e-learning pedagogical considerations. *The Internet and Higher Education, 4*(3-4), 287-299.

Gregor, S., Martin, M., Fernandez, W., Stern, S., & Vitale, M. (2006). The transformational dimension in the realization of business value from information technology. *The Journal of Strategic Information Systems*, *15*(3), 249-270.

Guetterman, T. C., Fetters, M. D., & Creswell, J. W. (2015). Integrating quantitative and qualitative results in health science mixed methods research through joint displays. *Annals of Family Medicine, 13*, 554-561.

Gulikers, J. T., Biemans, H. J., Wesselink, R., & van der Wel, M. (2013). Aligning formative and summative assessments: A collaborative action research challenging teacher conceptions. *Studies in Educational Evaluation*, *39*(2), 116-124.

Hall, L. K. (2019). *The impact of i-ready on middle school math students* (Order No. 13809795). Available from ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global; ProQuest One Academic. (2240074361).

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest*, *8*(1), 1-51.

Hannafin, R. D., & Foshay, W. R. (2008). Computer-based instruction's (CBI) rediscovered role in K-12: An evaluation case study of one high school's use of CBI to improve pass rates on high-stakes tests. *Educational Technology Research and Development*, *56*(2), 147-160.

Hattie, J. A. (2009). *Visible learning for teachers. A synthesis of over 800 meta-analyses relating to achievement.* New York, NY: Routledge.

Hedges, L. V. (1983). A random effects model for effect sizes. *Psychological Bulletin*, *93*(2), 388.

Hedges, W. D. (1981). Lightening the load with computer-managed instruction. *Classroom Computer News, 1*(6), 34.

Herring, S. C. (2000). Gender differences in CMC: Findings and implications. *Computer Professionals for Social Responsibility Journal, 18*(1).

Herring, S. C., & Stoerger, S. (2014). 29 gender and (a)nonymity in computer-mediated communication. *The Handbook of Language, Gender, and Sexuality, 2*, 567-586.

Hewitt, J., & Scardamalia, M. (1998). Design principles for distributed knowledge building processes. *Educational Psychology Review, 10*(1), 75–96. doi: 10.1023/A:1022810231840

Howe, N., & Strauss, W. (2000). *Millennials rising: The next great generation*. New York, NY: Vintage.

Howe, N., & Strauss, W. (2003). *Millennials go to college: Strategies for a new generation on campus: Recruiting and admissions, campus life, and the classroom*. Washington, DC: American Association of Collegiate Registrars and Admissions Officers.

Hsieh, P. A. J., & Cho, V. (2011). Comparing e-learning tools' success: The case of instructor–student interactive vs. self-paced tools. *Computers & Education, 57*(3), 2025–2038. doi: 10.1016/j.compedu.2011.05.002

Hudson, S. (2018). *The impact of cyber-bullying on adolescents' Georgia Milestones scores* (Order No. 10976909). Available from ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global; ProQuest One Academic. (2134031511).

Hunyadi, D., Pah, I., & Chiribuca, D. (2009). A global model for virtual educational system. *WSEAS Transactions on Information Science and Applications*, *6*(3), 374-383.

Iivari, N. (2018). Using member checking in interpretive research practice: A hermeneutic analysis of informants' interpretation of their organizational realities. *Information Technology & People, 31*(1), 111-133. https://doi.org/10.1108/ITP-07-2016-0168.

i-Ready (2018). *Teacher toolbox resource selector tool* [PDF file]. Retrieved from http://i-readycentral.com/all-resources/

Jackson, K. M., & Trochim, W. M. K. (2002). Concept mapping as an alternative approach for the analysis of open-ended survey responses. *Organizational Research Methods*, *5*(4), 307-336. https://doi.org/10.1177/109442802237114

Jeffrey, J. (1978). *Education for children of the poor: A study of the origins and implementation of the Elementary and Secondary Education Act of 1965.* Columbus: Ohio State University Press.

Johanningmeier, E. V. (2010). A nation at risk and Sputnik: Compared and reconsidered. *American Educational History Journal*, *37*(1/2), 347.

Johnson, C. (2017). Learning to program with game maker. *International Journal of Computer Science Education in Schools, 1*(2), 1-20.

Johnson, R. B., & Christensen, L. (2019). *Educational research: Quantitative, qualitative, and mixed approaches*. Thousand Oaks, CA. SAGE Publications.

Johnson, R. B., & Turner, L. A. (2003). Data collection strategies in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 297–319). Thousand Oaks, CA: SAGE Publications.

Johnson, E. S., & Smith, L. (2008). Implementation of response to intervention at middle school: Challenges and potential benefits. *Teaching Exceptional Children*, *40*(3), 46-52.

Jonassen, D. H., Grabinger, R. S., & Harris, N. D. C. (1990). Analyzing and selecting instructional strategies and tactics. *Performance Improvement Quarterly*, *3*(2), 29-47. doi:10.1111/j.1937-8327. 1997.tb00029.x

Jones, P. S., & Coxford Jr, A. F. (1970). Mathematics in the evolving schools. *National Council Teachers Math Yearbook* (32nd ed.), *9*(90), 70.

Jones, R. E., Yssel, N., & Grant, C. (2012). Reading instruction in tier 1: Bridging the gaps by nesting evidence-based interventions within differentiated instruction. *Psychology in the Schools*, *49*(3), 210-218.

Kane, J. (2018). A case study documenting the effects of response to intervention practices on mathematics success in elementary education. *Culminating Experience Action Research Projects, 18*(2), 40.

Katmada, A., Mavridis, A., & Tsiatsos, T. (2014). Implementing a game for supporting learning in mathematics. *Electronic Journal of e-Learning*, *12*(3), 230-242.

Ke, F. (2008). Computer games application within alternative classroom goal structures: Cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development, 56*(5–6), 539–556.

Kelly, D. P., & Rutherford, T. (2017). Khan Academy as supplemental instruction: A controlled study of a computer-based mathematics intervention. *The International Review of Research in Open and Distributed Learning*, *18*(4), 70 – 77.

Kessinger, T. A. (2011). Efforts toward educational reform in the United States since 1958: A review of seven major initiatives. *American Educational History Journal*, *38*(1/2), 263.

Kibuku, R. N., & Ochieng, D. O. (2019). Contributions and shortcomings of classical learning theories as applied to e-learning: A literature review. In *2019 IST-Africa Week Conference (IST-Africa)* (pp. 1-10). Dublin, IE: IEEE Publishing.

Kiger, D., Herro, D., & Prunty, D. (2012). Examining the influence of a mobile learning intervention on third grade math achievement. *Journal of Research on Technology in Education*, *45*(1), 61-82.

Kiili, K., Devlin, K., Perttula, A., Tuomi, P., & Lindstedt, A. (2015). Using video games to combine learning and assessment in mathematics education. *International Journal of Serious Games*, *2*(4), 37-55.

Kilpatrick, J. (1992). A history of research in mathematics education. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 3–38). New York, NY: Macmillan.

Kirakowski, J., & Corbett, M. (1993). SUMI: The software usability measurement inventory. *British Journal of Educational Technology*, *24*(3), 210-212.

Kiriakidis, P. P., & Geer, B. T. (2014). The effect of success maker software on state scores in elementary school math. *Romanian Journal for Multidimensional Education / Revista Romaneasca Pentru Educatie Multidimensionala, 6*(2), 127-138.

Klein, D. (2003). A brief history of American K-12 mathematics education in the 20th century. In J. M. Royer (Ed.), *Mathematical cognition: A volume in current perspectives on cognition, learning, and instruction* (pp. 175 – 225). Greenwich, CT: Information Age.

Knapp, T. R., & Schafer, W. D. (2009). From gain score t to ANCOVA F (and vice versa). *Practical Assessment, Research, and Evaluation*, *14*(1), 6.

Koizumi, R., & In'nami, Y. (2013). Vocabulary knowledge and speaking proficiency among second language learners from novice to intermediate levels. *Journal of Language Teaching & Research*, *4*(5), 900-913.

Koohang, A., Riley, L., & Smith, T. (2009). E-learning and constructivism: From theory to application. *Interdisciplinary Journal of E-Learning and Learning Objects*, *5*(1), 91-109.

Kosko, K. W., & Gao, Y. (2017). Mathematical communication in state standards before the Common Core. *Educational Policy*, *31*(3), 275-302.

Koulouri, T., Lauria, S., & Macredie, R. D. (2017). The influence of visual feedback and gender dynamics on performance, perception and communication strategies in CSCW. *International Journal of Human-Computer Studies, 97,* 162-181.

Küçükalkan, K., Beyazsaçlı, M., & Öz, A. Ş. (2019). Examination of the effects of computer-based mathematics instruction methods in children with mathematical learning difficulties: a meta-analysis. *Behaviour & Information Technology*, *38*(9), 913-923.

Kuhn, M., & Dempsey, K. (2011). End the math wars. *Learning & Leading with Technology*, *39*(3), 18-21.

Kulik, C. L. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior*, *7*, 75-94.

Lagemann, E. (2000). *An elusive science: The troubling history of education research.* Chicago, IL: University of Chicago Press.

Lappan, G., & Wanko, J. J. (2003). The changing roles and priorities of the federal government in mathematics education in the United States. *A History of School Mathematics*, *2*, 897-930. Reston, VA: National Council of Teachers of Mathematics.

Lee, J. (2008). Two takes on the impact of NCLB: Tracking statewide proficiency trends through NAEP vs. state assessment. In G. L. Sunderman (Ed.). *The NCLB challenge: Achieving accountability, equity and school reform* (pp. 75-89). Thousand Oaks, CA: Corwin Press.

Lee, A. S., & Baskerville, R. L. (2003). Generalizing generalizability in information systems research. *Information Systems Research, 14*(3), 221–243.

Lee, W., & Lutz, B. D. (2016). *An anchored open-ended survey approach in multiple case study analysis*. Paper presented at the ASEE Annual Conference & Exposition in New Orleans, LA. Retrieved from https://peer.asee.org/26566

Lee, J., & Wu, Y. (2017). Is the common core racing America to the top? Tracking changes in state standards, school practices, and student achievement. *Education Policy Analysis Archives*, *25*, 35.

Lei, J., & Zhao, Y. (2007). Technology uses and student achievement: A longitudinal study. *Computers & Education*, *49*(2), 284-296.

Leiblum, M. D. (1982). Computer-managed instruction: An explanation and overview. *Association for Educational Data Systems Journal, 15*(3), 127-142.

Levitan, S. A., & Taggart, R. (1976). The great society did succeed. *Political Science Quarterly*, *91*(4), 601-618.

Lewin, C., & McNicol, S. (2015). Supporting the development of 21st century skills through ICT. In T. Brinda, N. Reynolds, R. Romeike, & A. Schwill (Eds.), KEYCIT 2014: *Key competencies in informatics and ICT* (pp. 98-181). Potsdam, Germany: Universitätsverlag Potsdam.

Liao, Y., & Lin, W. H. (2016). Effects of matching multiple memory strategies with computer-assisted instruction on students' statistics learning achievement. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(12), 2921-2931. doi: 10.12973/ eurasia.2016.02313a

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: SAGE Publications.

Liu, I., Chen, M. C., Sun, Y. S., Wible, D., & Kuo, C. H. (2010). Extending the TAM model to explore the factors that affect intention to use an online learning community. *Computers & Education, 54*(2), 600–610. doi: 10.1016/j.compedu.2009.09.009

Lowrie, T., & Jorgensen, R. (2011). Gender differences in students' mathematics game playing. *Computers & Education*, *57*(4), 2244-2248.

Luck, L., Jackson, D., & Usher, K. (2006). Case study: a bridge across the paradigms. *Nursing Inquiry*, *13*(2), 103-109.

Maccini, P., & Gagnon, J. C. (2000). Best practices for teaching mathematics to secondary students with special needs: Implications from teacher perceptions and a review of the literature. *Focus on Exceptional Children, 32*(5), 1-22.

Mahmoudi, H., Koushafar, M., Saribagloo, J. A., & Pashavi, G. (2015). The effect of computer games on speed, attention and consistency of learning mathematics among students. *Procedia-Social and Behavioral Sciences*, *176*, 419-424.

Mallanda, C. (2011). *The effects of changing from a traditional mathematics curriculum to an integrated mathematics curriculum on student mathematics learning in Georgia*. Available from ProQuest Dissertations & Theses A&I. (916377526).

Maxwell, J. A. (2013). *Qualitative research design: An interactive approach* (3rd ed.). Thousand Oaks, CA: SAGE Publications.

McLaughlin, M. (1975). *Evaluation and reform: The Elementary and Secondary Education Act of 1965, Title I.* Cambridge, MA: Ballinger Publishing Company.

McLeod, D. B. (2003). From consensus to controversy: The story of the NCTM standards. *A History of School Mathematics*, *1*, 753-818. Reston, VA: National Council of Teachers of Mathematics.

McLoughlin, C., & Oliver, R. (1999). Instructional design for cultural difference: A case study of the indigenous online learning in a tertiary context. *Proceedings of the 16th annual conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 229–238). Brisbane, Australia: Queensland University of Technology.

Mechling, L. C., & O'Brien, E. (2010). Computer-based video instruction to teach students with intellectual disabilities to use public bus transportation. *Education and Training in Autism and Developmental Disabilities*, *45*, 230–242.

Mellard, D., McKnight, M., & Jordan, J. (2010). RTI tier structures and instructional intensity. *Learning Disabilities Research & Practice*, *25*(4), 217-225.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). San Francisco, CA: Jossey-Bass.

Moors, A., Weisenburgh-Snyder, A., & Robbins, J. (2010). Integrating frequency-based mathematics instruction with a multi-level assessment system to enhance response to intervention frameworks. *The Behavior Analyst Today*, *11*(4), 226.

Morales, A. (2016). *Using technology to aid in the differentiation of mathematics in a sixth grade classroom.* Retrieved from https://sophia.stkate.edu/maed/147

Moss, D. L., & Lamberg, T. (2019). Conceptions of expressions and equations in early algebra: A learning trajectory. *International Journal for Mathematics Teaching and Learning*, *20*(2), 170-192.

Mulqueeny, K., Kostyuk, V., Baker, R. S., & Ocumpaugh, J. (2015). Incorporating effective e-learning principles to improve student engagement in middle-school mathematics. *International Journal of STEM Education*, *2*(1), 15.

Murphy, E. (1997). *Constructivism: From philosophy to practice*. Retrieved October 19, 2008 from http://www.cdli.ca/~elmurphy/emurphy/cle.html

Myers, J., Wang, J., Brownell, M., &. Gagnon, C. (2015). Mathematics interventions for students with learning disabilities (LD) in secondary school: A review of the literature. *Learning Disabilities: A Contemporary Journal, 13(2),* 207–235.

National Committee on Mathematical Requirements. (1923). *The reorganization of mathematics in secondary education*. Retrieved from http://www.mathcurriculumcenter.org/PDFS/CCM/originals/reorg_of_math_report.pdf

National Council of Teachers of Mathematics. (1970). *A history of mathematics education in the United States and Canada*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1980). *An agenda for action: Recommendations for school mathematics for the 1980s.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and NCTM standards for school mathematics.* Reston, VA: Author.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards for mathematics.* Washington, DC: Author.

National Research Council. (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: The National Academies Press. https://doi.org/10.17226/9822

No Child Left Behind Act of 2001. (2002). Pub. L. No. 107-110, 115 Stat [Online]. Available http://www.ed.gov/legislation/ESEA02/index.html

Nwineh, L., & Okwelle, P. C. (2018). Acquisition of practical skills in domestic electrical installation: Computer simulation versus demonstration approach. *Journal of Technical Education and Training*, *10*(1).

Osborne, J. W., & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical Assessment, Research, and Evaluation*, *8*(1), 2.

Oliver, R., & Herrington, J. (2003). Exploring technology-mediated learning from a pedagogical perspective. *Journal of Interactive Learning Environments, 11*(2), 111-126.

Ozel, S., Yetkiner, Z. E., & Capraro, R. M. (2008). Technology in K-12 mathematics classrooms. *School Science & Mathematics, 108*(2), 80-85. doi: 10.1111/j.1949-8594. 2008.tb17807.x

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1–12.

Park, O., & Lee, J. (2003). Adaptive instructional systems. *Educational Technology Research and Development, 25,* 651-684.

Paul, C. A. (2016). *Elementary and Secondary Education Act of 1965.* Social Welfare History Project. Retrieved from http://socialwelfare.library.vcu.edu/programs/education/elementary-and-secondary-education-act-of-1965/

Pedhazur, E. J., (1997). *Multiple regression in behavioral research* (3rd ed.). Orlando, FL: Harcourt Brace.

Pereira, S. M., & Leslie, G. (2009). Hypothesis testing. *Australian Critical Care*, *22*(4), 187-191.

Peterson, P. E., Woessmann, L., Hanushek, E. A., & Lastra-Anadón, C. X. (2011). Are US students ready to compete?. *Education Next*, *11*(4), 50-59.

Plano Clark, V. L., Schumacher, K., West, C., Edrington, J., Dunn, L. B., Harzstark, A., Melisko, M., Rabow, M. W., Swift, P. S., & Miaskowski, C. (2013). Practices for embedding an interpretive qualitative approach within a randomized clinical trial. *Journal of Mixed Methods Research*, *7*(3), 219-242.

Porter, A. C., Kirst, M.W., Osthoff, E. J., Smithson, J. L., & Schneider, S. A. (1993). *Reform up close: An analysis of high school mathematics and science classrooms* (Final report to the National Science Foundation on Grant No. SAP-8953446 to the Consortium for Policy Research in Education). Madison, WI: University of Wisconsin-Madison, Consortium for Policy Research in Education.

Prenksy, M. (2001). Digital natives, Digital immigrants. *On the Horizon, 9*(5), 1-6.

Pritami, F. A., & Muhimmah, I. (2018). Digital game based learning using augmented reality for mathematics learning. In *Proceedings of the 2018 7th International Conference on Software and Computer Applications* (pp. 254-258). Malaysia: Association for Computing Machinery. doi: 10.1145/3185089.3185143.

Pugalee, D. K. (2001). Using communication to develop students' mathematical literacy. *Mathematics Teaching in the Middle School*, *6*(5), 296.

Raizen, S. A., D. B. McLeod, & M. B. Rowe. (1997). The changing conceptions of reform. In S. A. Raizen, and E. D. Britton (Eds.), *Bold ventures: Volume I: Patterns among U.S. innovations in science and mathematics* (pp. 97–129). Boston, MA: Kluwer Academic Publishing.

Ravid, R. (2019). *Practical statistics for educators* (4th ed.). Lanham, MD: Rowman & Littlefield Publishers.

Reimann, P., & Aditomo, A. (2013). Technology-supported learning and academic achievement. In *International guide to student achievement* (1st ed.). New York, NY: Routledge.

Renaissance Learning. (2016). *STAR Math: Technical manual.* Wisconsin Rapids, WI: Author. Retrieved from https://help.renaissance.com/US/PDF/SM/SMRPTechnicalManual.pdf

Resnick, D. P. (1980). Minimum competency testing historically considered. *Review of Research in Education, 8*, 3– 29.

Richland, L. E., Zur, O., & Holyoak, K. J. (2007). Cognitive supports for analogies in the mathematics classroom. *Science, 316*(5828), 1128 - 1129. http://dx.doi.org/10.1126/science.1142103.

Rodriguez, A. M. (2013). *An analysis of the experiences of transfer students participating in dual enrollment programs in the state of Florida* (Order No. 3584493). Available from ProQuest Central; ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global; ProQuest One Academic. (1547360192).

Roschelle, J., Feng, M., Murphy, R. F., & Mason, C. A. (2016). Online mathematics homework increases student achievement. *AERA Open*, *2*(4), 2332858416673968.

Rourke, L., & Anderson, T. (2002). Using peer teams to lead online discussions. *Journal of Interactive Media in Education, 2002*(1), Article 1. Retrieved from http://www-jime.open.ac.uk/jime/article/view/2002-1

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions, 6*(1), 46.

Rüth, M., & Kaspar, K. (2017). The e-learning setting circle: First steps toward theory development in e-learning research. *Electronic Journal of e-Learning*, *15*(1), 94-103.

Ryan, J. E. (2004). The perverse incentives of the No Child Left Behind Act. *New York University Law Review, 79*, 932–989.

Ryan, J. (2017). *The impact of computer-based instructional approaches on sixth-grade students' achievement in social studies.* Retrieved from http://hdl.handle.net/11603/4353

Sadovnik, A. R., O'Day, J. A., Bohrnstedt, G. W., & Borman, K. M. (Eds.). (2013). *No Child Left Behind and the reduction of the achievement gap: Sociological perspectives on federal educational policy*. New York, NY: Routledge.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Thousand Oaks, CA: SAGE Publications.

Sánchez-Prieto, J. C., Olmos-Migueláñez, S., & García-Peñalvo, F. J. (2016). Informal tools in formal contexts: Development of a model to assess the acceptance of mobile technologies among teachers. *Computers in Human Behavior, 55*, 519-528.

Sari, B. G., Lúcio, A. D. C., Santana, C. S., Krysczun, D. K., Tischler, A. L., & Drebes, L. (2017). Sample size for estimation of the Pearson correlation coefficient in cherry tomato tests. *Ciencia Rural*, *47*(10), 1 – 6. https://doi.org/10.1590/0103-8478cr20170116

Saunders, A. F., Spooner, F., & Ley Davis, L. (2018). Using video prompting to teach mathematical problem solving of real-world video-simulation problems. *Remedial and Special Education*, *39*(1), 53-64.

Savvani, S. (2018). State-of-the-art duolingo: Features and applications. *International Conference on Interactive Collaborative Learning, 917*, 139-148.

Schoenfeld, A. H. (2004). The math wars. *Educational Policy*, *18*(1), 253-286.

Securro, S., Jones, J. D., Cantrell, D., & Blackwell, J. (2006). Intervention that adds up: The impact of merit software on standardized achievement test scores of middle school students. *Journal on School Educational Technology*, *2*(1), 47-53.

Shapiro, E. S. (2014). *Tiered instruction and intervention in a response-to-intervention model*. Retrieved from http://www.rtinetwork.org/essential/tieredinstruction/tiered-instruction-and-intervention-rti-model#top

Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2011). Effects of technology immersion on middle school students' learning opportunities and achievement. *The Journal of Educational Research*, *104*(5), 299-315.

Sharp, L. A., & Hamil, M. (2017). The impact of Think Through Math© usage on middle school students' mathematics achievement. *MLET: The Journal of Middle Level Education in Texas*, *4*(1), 2.

Sheskey, B. (2010). Creating learning connections with today's tech-savvy student. In A. A. Jacobs (Ed.), *Curriculum 21: Essential education for a changing world* (pp. 195 – 209). Alexandria, VA: ASCD.

Slavin, R. E. (2006). *Educational psychology: Theory and practice*. Boston, MA: Pearson Education, Inc.

Smith, B. P. (2007). Employability standards: Inclusion in family and consumer science middle school curriculum. *Journal of Career and Technical Education*, *23*(1), 18-34.

Tapscott, D. (1998). *Growing up digital: The rise of the net generation.* New York, NY: McGraw-Hill.

Tate, W. F. (2000). Summary: Some final thoughts on changing the faces of mathematics. In W. G. Secada (Ed.), *Changing the faces of mathematics: Perspectives on African Americans* (pp. 201–207). Reston, VA: National Council of Teachers of Mathematics.

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences.* Thousand Oaks, CA: SAGE Publications.

Terrell, S. R. (2015). *Writing a proposal for your dissertation: Guidelines and examples*. New York, NY: Guilford Publications.

The Governor's Office of Student Achievement. (n.d.). *K-12 public schools report card.* Retrieved from https://gaawards.gosa.ga.gov/analytics/K12ReportCard

Tienken, C. H., & Maher, J. A. (2008). The influence of computer-assisted instruction on eighth grade mathematics achievement. *RMLE Online*, *32*(3), 1-13.

Treffers, A. (1987). *Three dimensions: A model of goal and theory description in mathematics instruction - The Wiskobas project.* Boston, MA: Kluwer Academic Publishers.

Twyman, J. S., & Sota, M. S. (2016). Educational technology and response to intervention: Affordances and considerations. In *Handbook of Response to Intervention* (pp. 493-517). Boston, MA: Springer.

Ukoha, U. A., & Eneogwe, U. N. (1996). The instructional process. *Curriculum development and educational technology.* Makurdi, Nigeria: Onaivi Printing and Publishing Company.

Ullman, M. T., Miranda, R. A., & Travers, M. L. (2008). Sex differences in the neurocognition of language. In J. B. Becker, K. J. Berklry, N. Geary, E. Hampson, J. P. Herman, & E. A. Young (Eds.), *Sex differences in the brain from genes to behavior* (pp. 291−309). Oxford, UK: Oxford University Press.

Unianu, E. M., & Purcaru, M. A. P. (2014). The impact of digital educational resources on learning mathematics. *eLearning & Software for Education*, (3), 431-434.

U.S. Department of Education (2013). *Using technology to support education reform.* Retrieved from http://www.ed.gov/methods/math

Vate-U-Lan, P. (2017). The oxymoron of serious games in eLearning: Gender differences from an internet-based survey in Thailand. *International Academic Conference on Teaching, Learning and E-learning in Budapest Hungary 2017 (IAC-TLEl 2017), 2017*(1), 6 – 17.

Vaughn, S., Cirino, P. T., Wanzek, J., Wexler, J., Fletcher, J. M., Denton, C. D., Barth, A., Romain, M., & Francis, D. J. (2010). Response to intervention for middle school students with reading difficulties: Effects of a primary and secondary intervention. *School Psychology Review, 39*(1), 3–21.

Virginia Department of Education. (2012). *Virginia standard of learning assessments: Technical report. 2011–2012 Administration cycle*. Richmond, VA: Author.

Vollmer, S. H., & George, H. (2010). Statistical power, the Belmont Report, and the ethics of clinical trials. *Science and Engineering Ethics, 16*, 675–691. doi: 10.1007 /s11948-010-9244-0

Wagner, S. T. (2006). *Eisenhower republicanism: Pursuing the middle way*. Dekalb, IL: Northern Illinois University Press.

Wakefield, D. V. (2017). Perfect storm hits Georgia schools: Teachers overwhelmed. *AILACTE Journal*, *14*(1), 69-101.

Walmsley, A. E. (2003). *The history if the "new mathematics" movement and its relationship with current mathematical reform.* Lanham, MD: University Press of America.

Walstad, W. B., & Soper, J. C. (1989). What is high school economics? Factors contributing to student achievement and attitudes. *The Journal of Economic Education*, *20*(1), 23-38.

Wanzek, J., & Vaughn, S. (2011). Is a three-tier reading intervention model associated with reduced placement in special education?. *Remedial and Special Education*, *32*(2), 167-175.

Watson, D. M. (2001). Pedagogy before technology: Re-thinking the relationship between ICT and teaching. *Education and Information Technologies, 6*(4), 251 266. http://dx.doi.org/10.1023/A:1012976702296

Webb, E. J., Campbell, D. T., Schwartz, R. D., Sechrest, L., & Grove, J. B. (1981). *Nonreactive measures in the social sciences* (2nd ed.). Boston, MA: Houghton Mifflin.

Wee, M. C., Abrizah, A., & Por, L. Y. (2012). Computer-Managed Instruction (CMI)-Based Online Forums. *Journal of Educational Computing Research*, *47*(2), 209-233.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity* (1st ed.). Cambridge, UK: Cambridge University Press.

Whitacre, I., & Nickerson, S. D. (2016). Investigating the improvement of prospective elementary teachers' number sense in reasoning about fraction magnitude. *Journal of Mathematics Teacher Education*, *19*(1), 57-77.

White, M. A. (1983). Synthesis of research on electronic learning. *Educational Leadership, 40*(8), 13-15.

Wong, K., & Nicotera, A. (2004). Brown v. Board of Education and Coleman Report: Social science research and the debate on educational equality. *Peabody Journal of Education, 79*(2), 122-135.

Woodward, J. (2004). Mathematics education in the United States: Past to present. *Journal of Learning Disabilities*, *37*(1), 16-31.

Worthen, B. R., White, K. R., Fan, X., & Sudweeks, R. R., (1999). *Measurement and assessment in schools* (2nd ed.). Reading, MA: Addison Wesley Longman.

Wright, P. (2012). The math wars: Tensions in the development of school mathematics curricula. *For the Learning of Mathematics*, *32*(2), 7-13.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education, 62*(3), 41–49. doi: 10.1016/j.compedu.2012.10.024

Yilmaz, B. (2017). *Effects of adaptive learning technologies on math achievement: A quantitative study of ALEKS math software* (Order No. 10281040). Available from ProQuest Dissertations & Theses A&I. (1906301379).

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: SAGE Publications.

Yin, R. K. (2006). Mixed methods research: Are the methods genuinely integrated or merely parallel? *Research in the Schools, 13*(1), 41-47.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Los Angeles, CA: SAGE Publications.

Young, J. L., Young, J. R., & Capraro, M. M. (2017). Black girls' achievement in middle grades mathematics: How can socializing agents help?. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *90*(3), 70-76.

Zhang, M., Trussell, R. P., Gallegos, B., & Asam, R. R. (2015). Using math apps for improving student learning: An exploratory study in an inclusive fourth grade classroom. *TechTrends*, *59*(2), 32-39.

Zhang, Y., & Wildemuth, B. M. (2009). Unstructured interviews. *Applications of Social Research Methods to Questions in Information and Library Science*, 222-231.

Ziegler, E., & Stern, E. (2016). Consistent advantages of contrasted comparisons: Algebra learning under direct instruction. *Learning and Instruction*, *41*, 41-51.

Zinn, K. L. (2000). Computer-assisted learning and teaching. In *Encyclopedia of computer science* (pp. 328–336). Chichester, UK: John Wiley and Sons Ltd. Retrieved from http://dl.acm.org/citation.cfm?id=1074100.1074248

APPENDICES

Appendix A

IRB Approval Email

Institutional Review Board
Columbus State University

Date: 11/04/2020
Protocol Number: 21-036
Protocol Title: THE RELATIONSHIP BETWEEN I-READY INTERVENTION AND GRADE 8 MATHEMATICS ACHIEVEMENT

Principal Investigator: Kenyatta Aldridge
Co-Principal Investigator: Jennifer Brown

Dear Kenyatta Aldridge,
The Columbus State University Institutional Review Board or representative(s) has reviewed your research proposal identified above. It has been determined that the project is classified as exempt under 45 CFR 46.101(b) of the federal regulations and has been approved. You may begin your research project immediately.

Please note any changes to the protocol must be submitted in writing to the IRB before implementing the change(s). Any adverse events, unexpected problems, and/or incidents that involve risks to participants and/or others must be reported to the Institutional Review Board at irb@columbusstate.edu or (706) 507-8634.

If you have further questions, please feel free to contact the IRB.
Sincerely,

Andrew Dorbu, Graduate Assistant

Institutional Review Board
Columbus State University

Appendix B

Superintendent's Email

Good evening,

My name is Kenyatta Aldridge, a doctoral candidate in the Doctorate of Curriculum and Instruction program at Columbus State University. I am interested in exploring the relationship of i-Ready Math with 8th grade students in your school district who have been identified as performing below grade level (Tier II and III). I would like to analyze data from student's 2018 – 2019 i-Ready data and GMAS domain scores. I would also like to interview teachers who taught eighth-grade students with the i-Ready program. If you would like additional information on the study please email me at aldridge_kenyatta@columbusstate.edu. Please respond back to this email with a letter of cooperation, with the school's letterhead, informing me if your school district will participate in the study.

Thank you,

Kenyatta Aldridge

Appendix C

Letter of Cooperation

[redacted]

October 13, 2020

International Review Board
Columbus State University
4225 University Ave.
Columbus, GA 31907

To Whom It May Concern:

Kenyatta Aldridge has requested permission to collect research data from i-Ready pretest and posttest scores from the 2017-2018 and from the 2018-2019 school years and interviews with the two Grade 8 mathematics teachers through a research study entitled The relationship between i-Ready intervention and Grade 8 mathematical achievement. I have been informed of the purposes of the study and the nature of the research procedures. I have also been given an opportunity to ask questions of the researcher.

[redacted] Schools has policies in conjunction with parents and the US Department of Education regarding the following:

A. The right of parents to inspect, upon request a survey created by a third party before the survey is administered or distributed by a school to students.
B. Arrangements to protect student privacy in the event of the administration of a survey to students, including the right of parents to inspect, upon request, the survey, if the survey contains one or more of the same eight items of information.
C. The right of parents to inspect, upon request, any instructional materials used as part of the educational curriculum for students.
D. The administration of physical examinations or screenings that the school may administer to students.

As a representative of [redacted] Schools, I am authorized to grant permission to have the researcher recruit research participants from [redacted] Kenyatta Aldridge is also permitted to collect research data after instructional hours and at [redacted] Office. The researcher has agreed to the following restrictions: no contact during school hours/no second contact for recruitment/will only contact participants virtually and provide a copy of published conclusions or results.

If you have any questions, please contact me at (229) 931-8500.

Sincerely,

[redacted]

Appendix D

Assistant Superintendent's Email

Hello:

My name is Kenyatta Aldridge, and I am a doctoral student at Columbus State University, Columbus, Georgia. The study is entitled: "The relationship between i-Ready intervention and eighth grade mathematics achievement." The purpose of the study is to determine the relationship between the i-Ready Math program on eighth-grade achievement for students performing below grade level in mathematics. My study will address the effectiveness of i-Ready Math intervention and how it impacts student achievement at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding math interventions for students performing below grade level.

I have received authorization from the superintendent, Dr. [redacted], to obtain 2018 - 2019 GMAS data for 8th grade students. When gathering the data, my study will focus on students who received Tier II and III intervention services. From the GMAS data, I would need data from each domain on the assessment. If a student repeated the 8th grade, I would need their first set of data from i-Ready.

In the event you have questions or require additional information, you may contact me at: email aldridge_kenyatta@columbusstate.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Jennifer Brown, email: brown_jennifer2@columbusstate.edu; or the CSU's Institutional Research Review Board: Dr. Jennifer Brown, IRB Chair, brown_jennifer2@columbusstate.edu.

Thank you for your participation.

Appendix E

Recruitment Email

Hello:

I am a doctoral candidate in the Doctorate of Curriculum and Leadership program at Columbus State University. I am interested in exploring the relationship of i-Ready Math with 8th grade students at your school who have been identified as performing below grade level. I would like to conduct a virtual interview (date and time) to understand your perceptions of implementing the i-Ready program. This interview will occur during non-instructional time and your participation is voluntary. The interview will last for approximately 30 minutes. Please email me at aldridge_kenyatta@columbusstate.edu to confirm your participation in the study, and to identify a date and time for the interview.

Thank you,

Kenyatta Aldridge

Appendix F

Informed Consent for Adult Participant Interview

COLUMBUS STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

Informed Consent Form

You are being asked to participate in a research project conducted by Kenyatta Aldridge, a student in the Doctoral program at Columbus State University. Dr. Jennifer Brown, Associate Professor of Educational Foundations, will be supervising the study.

I. Purpose:

The purpose of this project is to determine the relationship between the computer-managed instruction, i-Ready, and mathematical achievement as measured by the Georgia Milestones Assessment Scores (GMAS). .

II. Procedures:

1. The researcher will email the Grade 8 teachers, asking them to voluntarily participate in the study.
2. Informed Consent Forms will be emailed to the participants who express a desire to participate in the study.
3. Upon receiving his or her signed Informed Consent Form, the researcher will schedule a time for a virtual interview on a mutually agreed upon day and time.
4. The researcher will conduct the online interview (GoToMeeting), which will last approximately 30 minutes, using the open-ended questions from the interview protocol. For each interview, the researcher will collect data with the GoToMeeting software, and an audio digital recorder.
5. Once the interviews have been conducted, the researcher will use Microsoft Word to transcribe the data and hand code the data.
6. After transcribing and coding the interviews, the researcher will email the transcribed data to participants to allow for member checking.
7. The participants will have 30 days from the initial email to make corrections and check the transcribed interviews.
8. If the participants email the researcher changes to the transcript, the researcher will make the necessary changes and resubmit the transcribed interview back to the participants.

The data from this study could be used for future projects.

III. Possible Risks or Discomforts:

The study will not cause physical or psychological risks to the particpants. The study will not use any deceptive techniques with the particpants, and will not cause discomfort to the participants. The study will not cause any risk to the participants social or economic status.

IV. Potential Benefits:

The findings of this study could provide stakeholders, teachers, and students with the knowledge about the relationship between the intervention program and student achievement. Discovering teachers' perceptions of the i-Ready program's implementation could present district leaders with information regarding the type of professional development needed to support teachers.

V. Costs and Compensation:

The teachers will not receive any financial benefit from participating in this study.

VI. Confidentiality:

The researcher will ensure that the subjects' confidentiality is maintained by storing all electronic files on a password-protected computer within the PI's home office and by storing all paper files (e.g., signed informed consents and field notes) in a locked cabinet within the PI's home office. Only the PI and Co-PI will have access to the data. Five years after the dissertation's publication, the data will be disposed by deleting all of the electronic versions of the data from hard drive storage and shredding all paper documents.

The interviews will take place virtually and after school hours. There is the possibility that the interviewer's or the interviewee's internet service will be interrupted. If this event occurs, the researcher will stop the interview and resume after the interviewee and interviewer establish internet connection.

VII. Withdrawal:

Your participation in this research study is voluntary. You may withdraw from the study at any time, and your withdrawal will not involve penalty or loss of benefits.

For additional information about this research project, you may contact the Principal Investigator, Kenyatta Aldridge at 229-944-3802 or aldridge_kenyatta@columbusstate.edu. If you have questions about your rights as a research participant, you may contact Columbus State University Institutional Review Board at irb@columbusstate.edu.

I have read this informed consent form. If I had any questions, they have been answered. By signing this form, I agree to participate in this research project.

____________________________________ Signature of Participant

________________ Date

Appendix G

Teacher Interview Protocol

I am currently a doctoral student at Columbus State University, completing my dissertation, “The relationship between i-Ready intervention and eighth grade mathematical achievement.” As part of my research, I would like to conduct an online interview to assess teacher perceptions on the implementation of the i-Ready intervention program as to eighth-grade students who receive Tier II and III mathematics intervention. Your participation is voluntary, and I would like to thank you in advance for your consideration.

1. What is your title?
2. Years of experience in education? _______
3. Years of experience in your current role?
4. Explain how you ensured that students identified as performing below grade level in mathematics utilized i-Ready Math for a minimum of 30 minutes per week.
5. What were some professional learning opportunities the district provided to help implement the i-Ready Math program?
6. What are some possible professional learning opportunities that need to be provided to teachers to implement the i-Ready Math program?
7. What are some challenges you have observed with the implementation of the i-Ready Math program?
8. What are some benefits you have observed with the implementation of the i-Ready Math program?

9. If student achievement did not increase, what do you believe were the contributing factors?

10. If student achievement did increase, what do you believe were the contributing factors?

11. Do you have a positive or negative perception about the i-Ready Math intervention program? Why?

12. Is there anything else you would like to discuss about the i-Ready Math program?

Appendix H

Member Checking Transcribed Interview Email

Hello:

I am sending the transcribed interview that was completed on ______________ to assess perceptions of the implementation of i-Ready Math instruction as an intervention for 8th grade students that receive Tier II and III mathematics intervention. Member checking will allow you to check for accuracy and quality of the data. You can verify, clarify, or elaborate on the answers you provided for the questions. Once you have checked the transcribed interview, email the document back to aldridge_kenyatta@columbusstate.edu if any corrections need to be made by the researcher, she will make the corrections and send the transcribed interview back to you. You will have 30 days from the date of the email to send back any corrections to the transcribed interview.

Thank you for your participation.

Kenyatta Aldridge

Appendix I

Email to Response to Intervention Specialist

Hello:

My name is Kenyatta Aldridge, and I am a doctoral student at Columbus State University, Columbus, Georgia. The study is entitled: "The relationship between i-Ready intervention and eighth grade mathematical achievement." The purpose of the study is to determine the relationship between the i-Ready Math program on eighth-grade achievement for students performing below grade level in mathematics. My study will address the effectiveness of i-Ready Math intervention and how it impacts student achievement at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding math interventions for students performing below grade level.

I have received authorization from the superintendent, Dr. Choates, to obtain 2018 - 2019 i-Ready data for 8th grade students. When gathering the data, my study will focus on students who received Tier II and III intervention services. From the i-Ready program, I would need data from August 2018 - May 2019 that includes the number of lessons students completed, the participant's gender, and the pretest and posttest scores. If a student repeated the 8th grade, I would need their first set of data from i-Ready.

In the event you have questions or require additional information, you may contact me at aldridge_kenyatta@columbusstate.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Jennifer Brown, email: brown_jennifer2@columbusstate.edu; or the CSU's Institutional Research Review Board: Dr. Jennifer Brown, IRB Chair, brown_jennifer2@columbusstate.edu.

Thank you for your participation.