THE EFFECT OF COMPUTER-ASSISTED INTERVENTION PROGRAMS ON MATHEMATICS ACHIEVEMENT OF HIGH SCHOOL STUDENTS IN A VIRTUAL SCHOOL

by

Brandi Rachelle Robinson

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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ABSTRACT

The United States ranks in the middle of the nations participating in the Programme for International Student Assessment, and secondary education has not seen growth in mathematics achievement since the 1970s. Computer-assisted math education offers a new opportunity to increase mathematical achievement with students. Pearson Education's MyMathLab has shown promise at the higher education level with enhancing student proficiency in concepts. The purpose of this study was to determine if the use of Math XL, the secondary counterpart to MyMathLab, could increase mathematics achievement, measured by the performance on the end-of-course test for Algebra I and Geometry for high school students in a computer-assisted math intervention program. The quasi-experimental posttest-only study enhanced the current knowledge of MyMathLab/Math XL as a tool for higher education and demonstrated the effects of using it at the secondary level. The sample was taken from high school Algebra I and Geometry students at an online high school in a southern state. A comparison group was created from students meeting the same criteria for the computer-assisted math intervention program who chose not to participate. An analysis of variance was used to test for statistically significant differences in the end-of-course test scores in those students enrolled in a computer-assisted math intervention program and those students not enrolled in a computer-assisted math intervention program. The analysis found no significant difference in the mean between the group enrolled in computer-assisted intervention and those not enrolled.

Keywords: computer-assisted technology, response to intervention, active learning theory, mathematics achievement, MyMathLab.

Dedication

I dedicate this work to my husband, who has been steadfast throughout this journey. He has endured life with a perpetual student, never really knowing what it is like not to have a wife in school. He has bought portable chargers, drove so I could do schoolwork, and put his goals second to my schooling. He has experienced life as a swim dad, where mom is on the computer until her son's heat. He has always been my biggest supporter, never doubting that I would make it to the final part of this journey.

I dedicate this work to my children. To Jacob, who taught me to dream big and work hard. His own acting career and his positivity in the face of rejection taught me to be fearless in the pursuit of my dreams. To Sara-Rachelle, our tiny dancer, who inspires me daily with her challenges of being on the autism spectrum. She handles her challenges with grace and works tirelessly toward her goal of being a prima ballerina. She has taught me the true meaning of perseverance. To Mae Mae, who never fails to be her own person and never conforms to the expectations of society. She has taught me to be secure in my own identity and to value individuality.

I dedicate this to my parents and grandmother, who read stories of girls that became a President to me as a child. They have supported my journey and stretched me as they provided for me to attend Louisiana School for Math, Science, and the Arts, where I first learned to love academics.

I could not have done this without the support of my family and friends. Each of them fills in the pieces to our puzzle of beautiful chaos.

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List of Abbreviations

The following are a list of abbreviations for wording used within this dissertation:

- analysis of variance (ANOVA),
- Center for Research of Educational Outcomes (CREDO),
- end-of-course (EOC),
- institutional review board (IRB),
- International Association for the Evaluation of Educational Achievement (IEA),
- Louisiana Educational Assessment Program (LEAP),
- National Center for Education Statistics (NCES),
- Organization for Economic Cooperation and Development (OECD),
- Programme for International Student Assessment (PISA),
- process-oriented guided inquiry learning (POGIL), and
- response to intervention (RTI).

CHAPTER ONE: INTRODUCTION

Overview

The background information on mathematics achievement and computer-assisted learning is presented in Chapter One, which highlights the historical, social, and theoretical context for this causal-comparative study. Chapter One includes the problem statement, significance of the study, research questions, and definitions pertinent to the topic.

Background

The United States consistently scores lower than other countries in mathematics achievement and readiness for mathematics in higher education (Lee, 2012; NCES, 2015a; OECD, 2013). The Programme for International Student Assessment (PISA) is a worldwide assessment that seeks to measure the educational systems in various countries by testing students who are roughly 15 years of age. The results are analyzed by country, and a ranking is released as a part of the results. According to the OECD (2013), the United States performed below the average score on the PISA in 2006 and fell even further below the average in 2012. Approximately 6,000 students took the PISA in 2012 representing 161 schools (NCES, 2008; OECD, 2013). The United States has experienced a crisis in international education rankings and competitiveness according to these benchmarks. American students may lack the readiness in mathematics to pursue a post-high-school degree from a higher education institution and, in some cases, even graduate (Lee, 2012). As a result, universities have increased the number of remedial mathematics classes offered (Vilardi & Rice, 2014). In fact, Gresham and Little (2012) determined that about 20-25% of students in the American secondary education system need additional services to be successful in the mathematics classroom. These students often fall under special education or response to intervention (RTI). Computer-assisted technology programs offer a way to increase mathematics achievement in general classrooms and computer-assisted math intervention programs. Using computer programs, students identify deficiencies in performance from interaction with the program (Demir & Basol, 2014). This rich feedback can be used to satisfy the requirements of RTI legislation and drive individualized instruction for students in an RTI program (Demir & Basol, 2014). Studies have shown an increase in mathematics achievement with the use of computer-based learning programs, enabling an increase in individualized instruction without the addition of a large number of teachers (De Witte, Haelermans, & Rogge, 2014; Wilder & Berry, 2016; Ye & Herron, 2012).

Historical Context

According to the NCES (2015a), in 2012, the average score for mathematics achievement in 17-year-olds did not vary measurably from scores in 1971. Additionally, scores in 2012 showed no measurable change from those in 2008. This may indicate a lack of achievement growth for the United States. Wagner (2008) cited repercussions of the achievement gap in science, technology, engineering, and mathematics (STEM) fields and described the lack of preparedness for higher-paying jobs based on the low achievement in STEM fields not preparing students for postsecondary education. Despite knowledge of this gap and the repercussions, achievement did not increase from 2008 to 2012, according to the NCES (2015a). In addition, as Lee (2012) showed, American students as a whole are not adequately prepared for higher education. Based on the NCES results, this could imply that students remained unprepared for the pursuit of higher education, as in 2008, scores did not change. Additionally, it is estimated that 80% of students are successful in the general education classroom; however, that leaves another 20% who should be addressed through RTI or special education services. Despite the low performance in the studies provided by Lee (2012) and NCES (2015a), 20% will not complete the math curriculum in a standard classroom without assistance (Kuo, 2014).

Before 1975, students with disabilities were a largely unaddressed segment of the educational population. Special education gained ground in 1975 with Public Law 94-142, which stated that all children with disabilities would have a right to an appropriate education (Antrim & Robins, 2013). This was taken a step further in 2004 when RTI was written into the Individuals with Disabilities Education Act (IDEA). The RTI portion of the law requires a system that uses performance data to drive instruction and a problem-solving approach that enhances student learning (Turse & Albrecht, 2015). The use of a computer learning program accomplishes this goal by bringing the focus to the students' individualized needs and identifying deficits. A computer-assisted learning program can also create a tailored plan to address students' deficits, which meet the requirements of RTI legislation or can assist a struggling mainstream student (Demir & Basol, 2014). Initially, RTI was in response to test scores; however, today, many educators also see this as a way to help students achieve grade-level expectations or bridge deficits in a content area. While RTI was written into the law, it did not include a legal mandate for districts to implement the process. Thus, the process is widely varied between programs. The common components include identifying students who have deficits in math and placing them in the appropriate intensity level and frequent monitoring of students' progress (Antrim & Robins, 2013). Regulation of RTI is lacking due to multiple delivery methods for an intervention. Schools have many choices of programs and the manner in which they implement an intervention program for each discipline (Daly, Martens, Barnett, Witt, & Olson, 2007). Lawmakers were committed to the idea so intently that they allowed districts with disproportionate representation of special education students to use up to 15% of their federal special education funding for RTI (Antrim & Robins, 2013). In RTI, the computer applications are utilized to practice repetition to master concepts, as well as to construct new knowledge when a slight variation in the problem occurs (Abbas, Lai-Mei, & Ismail, 2013). RTI serves not only special education students but also struggling students.

In the RTI program, students who cannot reach the benchmarks for the course are identified before they fail. Some students involved in intervention programs are simply low-performing for that content area and are not necessarily learning disabled. A learning disability does not predict placement in RTI. (Daly et al., 2007). The goal of RTI is to bring students to the grade-level expectations of a course (Antrim & Robins, 2013). By doing this, more students see an increase in math achievement to bridge the international gap and to prepare for higher learning (Lee, 2012; OECD, 2013).

Social Context

The estimated success rate of students in a math curriculum is 80% (Kuo, 2014). However, that leaves another 20% who may benefit from RTI or special education services (Kuo, 2014). This is applicable to the virtual environment as well as the traditional classroom. While RTI was being implemented in 2004 (Antrim & Robins, 2013), trends on the PISA and findings from the NCES indicated that gaps were not being adequately addressed (NCES, 2008; NCES, 2015a; OECD, 2013). These gaps have led to a lack of readiness for higher education (Lee, 2012). As Wagner (2008) explained, the lack of preparedness for mathematics at a postsecondary level continues to perpetuate the lack of STEM-field graduates. This leaves the United States with shortages in key fields such as engineering, medicine, technology, and others. In addition, Wagner (2008) indicated that for individuals to be successful in society, they need some sort of postsecondary education. Wagner estimated that 85% of jobs require postsecondary education and this is expected to continue to grow. If the school system does not adequately prepare students for postsecondary education, this can result in citizens taking lower-paying jobs and a lower tax base for the nation.

It is possible that a computer-assisted learning program, in a virtual school setting, would offer a way to individualize instruction for disadvantaged schools and students who require additional help to be successful in the traditional math classroom without adding more grading responsibility and lesson planning to teachers (Vilardi & Rice, 2014). It would also aide in providing individual instruction to students without needing to increase the number of faculty present at a disadvantaged school. The body of knowledge regarding computer-assisted learning programs should be expanded to close, at least some of, the global achievement gap in mathematics. By closing the gap, graduates of secondary schools are better prepared to pursue postsecondary education and, therefore, would be able to support themselves better by having higher-paying jobs.

Theoretical Context

Peirce (1982) fathered the idea of active learning theory, a student-centered instructional strategy that uses process oriented guided learning (POGIL). His theory is similar to that of Vygotsky, and some even believe that Charles Peirce influenced Vygotsky's theories. Peirce's work predates that of Vygotsky and is more closely related to the interaction between a guiding force as an inquiry-based learning strategy (Chesters, 2012). This differs from other hands-on theories, as Peirce examined teaching using an inquiry model that does not necessarily involve hands-on activities and experiences. Although most of his papers were published after his death, Peirce is still credited with fathering active learning theory. Peirce advocated guided inquiry learning as opposed to direct instruction, as well as continuity of experience by participants, comprising a foundation to be built on in the classroom. Peirce believed that teachers should not give direct instruction to students but should guide them with thought-provoking prompts that allow the students to make conclusions of their own (Liszka, 2013). Peirce explained that if someone only learned from books, then the concepts would react incompatibly when a student needed to apply them to the real world (Buchler, 2016).

Recently, active learning theory has come to the forefront of educational discussions with regard to the use of computer-assisted technology in mathematics classrooms (Gulwani, 2014; Lerman, 2012). Active learning theory centers around active learning, not passive processes such as lecturing (Liszka, 2013). Active learning theory drove this study, as the use of a computer-assisted learning program allowed the students to interact with the software to learn the material as they worked through assignments (Gulwani, 2014). Students were in a virtual setting and as such have an option at a computer-assisted math intervention program to supplement the standard curriculum. In the program, students complete guided inquiry designated by the instructor or the program itself to master areas of deficit in mathematics (Demir & Basol, 2014; Wilder & Berry, 2016; Ye & Herron, 2012). Generating dynamic problems for practice consumes valuable time for the teacher. It takes time away from other instructional tasks; however, computer-assisted learning programs can generate large databanks of problems with specific characteristics for solving. This allows the instructor to bring more focus back to student-centered learning and utilizing the program for additional inquiry-based learning, which allows students to ask for help or see examples of problems as they complete assignments. By asking for help, through the software, students learn more than with textbook problems, as they can continue to practice based on their own inquiries.

Computer-assisted learning programs can provide immediate feedback to a solution, whereas a teacher needs time to grade (Vilardi & Rice, 2014). This process has the potential to give students nearly unlimited practice with the concept and to receive instantaneous feedback on solutions. Computer-assisted learning programs also fit the description of POGIL (Moog & Spencer, 2008). Through the repetition available in the computer-assisted learning programs, students can put a greater focus on understanding the more complex concepts as procedures become rote (Doerr & Zangor, 2000). Furthermore, a computer-assisted math intervention program forms a continuity of experience as required by Peirce (1982) for active learning to take place.

Problem Statement

Secondary math achievement in the United States continues to remain below international expectations and the preparation level for postsecondary education (Lee, 2012; NCES, 2015a; OECD, 2013). While research concerning math intervention proliferates (Demir & Basol, 2014; Ye & Herron, 2012; Vilardi & Rice, 2014), research has largely neglected the secondary level implementation of computer-assisted learning programs. A handful of studies exist at the elementary and higher education levels on the use of computer-assisted technology to increase mathematics achievement (Hu et al., 2012; Wilder & Berry, 2016; Ye & Herron, 2012). Studies at the university level have shown a positive relationship between the use of MyMathLab (the higher education version of Math XL), or similar programs, and math achievement (Demir & Basol, 2014; Ye & Herron, 2012). A small number of studies have shown a negative impact. In this study, the students who utilized computer-based learning methods scored lower in a college math course than those who attended a traditionally instructed course (Vilardi & Rice, 2014). A small amount of scholarly research exists on the effectiveness of computer-based math programs used to increase mathematical achievement for grades 9-12. Several small sample studies have been completed using various computer-based learning programs to work to increase mathematical achievement. Students worked after school or in alternate classroom settings with computer-based learning programs as supplements to instruction (De Witte et al., 2014; Wilder & Berry, 2016). NCES (2015a) reported the largest gap in math achievement at the secondary level; however, available studies lack information on the application of computer-assisted learning programs at the high school level. The problem is that while secondary mathematics achievement in the United States is low, and current literature calls for better interventions to increase math achievement, little is known about the effectiveness of interaction-based programs designed to increase math understanding.

Purpose Statement

The purpose of this causal-comparative study was to determine if the use of a computer-assisted learning-based intervention program increases mathematics achievement at the secondary level. Mathematics achievement was the dependent variable and was defined as the score on the EOC exam. The variable was measured by the achievement score (i.e., needs improvement, fair, good, or excellent) on the Algebra I or Geometry EOC test (Louisiana Department of Education [LDOE], 2015). This achievement score was determined and measured by the grade in the course and performance on the EOC test for Algebra I and Geometry students. Mathematics achievement was examined based on the performance on the state EOC test for the particular subject. The study utilized the independent variable of computer-assisted learning-based intervention, which was defined as the use of a computer-based math learning program. This variable was measured by whether students opted into an additional preparation work in a computer-based learning program. Computer-based learning programs allow for quality interaction for students within the software that guide students with tools that explain key concepts or show step-by-step solutions (Demir & Basol, 2014).

Significance of the Study

This study is important to secondary education, as it examined the difference in math achievement between online instruction only and supplementing online instruction with computer-assisted learning programs. According to NCES (2015a), educational methods employed in mathematics from 1971 to 2012 failed to increase math achievement in 17-year-old students. Computer-assisted learning programs have the potential to improve math achievement in a secondary education setting, as seen by studies conducted at the postsecondary level (Hu et al., 2012; Wilder & Berry, 2016; Ye & Herron, 2012). Additionally, studies have shown improvement at the elementary level through the use of computer-assisted learning programs to increase the retention of procedural problems and operations (Burns, Kanive, & DeGrande, 2012; Hu et al., 2012). Wilder and Berry (2016) demonstrated successful integration of a computer-assisted learning program in secondary math for Algebra I. Their study demonstrated higher retention for those students who used the emporium course with integrated computer-assessed learning resources to engage in active learning. This study built on the preceding by examining targeted assignments and outcomes for Algebra I and Geometry in terms of standardized test scores. By improving these scores, students have better access to higher education preparatory courses to lead to more productive jobs and better quality of life through higher-income jobs.

More research is needed to determine the relationship between the use of computer-assisted learning programs and student achievement at the secondary level. RTI programs also call for rich feedback and continual assessment of student skill levels. Valid, reliable, and accurate implementation of RTI plans is necessary for student success (Martinez & Young, 2011). A computer-assisted learning program provides detailed reports to the instructor that can guide further instruction (Demir & Basol, 2014). The focus of this study was to understand better the connection between a computer-assisted learning program and a RTI program to increase mathematic achievement for struggling students. As well as to examine whether Math XL, a common computer-assisted learning program, could increase mathematics achievement. As a result of research at the secondary level, key stakeholders in RTI, special education, and even the general classroom have more information on the integration of technology in the math classroom and its relationship to math achievement.

Results from this study could influence intervention practices locally, as well as on a larger scale. Social and behavioral skills in the classroom could also be affected by this study. In several studies, researchers have found a relationship between academic skills and social behaviors. Students who scored higher on tests and have higher averages in coursework have better social, emotional, and decision-making skills (Algozzine, Putnam, & Horner, 2012). An effective intervention program could positively affect student behavior due to increased academic achievement.

Research Questions

The following research questions guided this study:

RQ1: Is there a statistically significant difference in mathematics achievement as measured by the Louisiana EOC test between students in Algebra 1 who receive computer-assisted math intervention and students who do not receive computer-assisted math intervention?

RQ2: Is there a statistically significant difference in mathematics achievement as measured by the Louisiana EOC test between students in Geometry who receive computer-assisted math intervention and students who do not receive computer-assisted math intervention?

Definitions

The following definitions are of terms used in this dissertation:

- *computer-assisted math education*—the integration of computers for positive results in the math education process where students identify their deficiencies and performance level through mutual interaction; students also receive feedback on the work completed (Demir & Basol, 2014);
- *EOC test*—A Louisiana-based standardized test that assesses proficiency in key concepts in a course to determine if a student is ready to move on; passing this is also a requirement for graduation (LDOE, 2015);
- *Programme for International Student Assessment*—an assessment used internationally by the Organization for Economic Cooperation and Development to determine if students at the end of their compulsory education have the skills and knowledge necessary for full participation in modern society (OECD, 2013); and
- *response to intervention*—an educational program authorized in IDEA to provide current intervention in reading or math for students who are behind their peers or benchmarks for their particular grade level (Antrim & Robins, 2013).

CHAPTER TWO: LITERATURE REVIEW

Overview

Active learning formed the theoretical foundation for this quasi-experimental posttest-only study. Active learning theory lies at the foundation of the student-centered learning software, Math XL, used in this study. This study demonstrated the gaps in the current understanding of the application of active learning theory in a mathematics classroom through technology applications. Furthermore, key literature on concepts relevant to the population of the study, such as online schools, implementation of computer-assisted mathematics education, accountability, and achievement in traditional and virtual schools, was examined through the lens of a researcher.

Theoretical Framework

When recalling student-centered learning theories, most credit John Dewey with having the largest impact on classroom pedagogy in present-day education. However, Charles Peirce's thinking on pragmatism had a profound impact on Dewey's theory (Dewey, 1938), although Peirce is not typically credited with contributing to the literature on active learning theory. This could be due to Peirce's lack of finished writings on education during his lifetime. Active learning forms the foundation of the theory used in this study and advocates for a student-centered learning experience that requires engagement in the subject matter. Engagement and student-centered learning are often included in best practices and teacher training programs. In place of lecture or other teacher-centered methodologies, students and their learning experiences form the central theme of the classroom. Key classroom pedagogies relevant to this study that employ this learning style include process oriented guided inquiry learning (POGIL) and inquiry-based learning. Peirce rejected pushing knowledge on students and, in place of it, favored generating curiosity in his students. Pierce did not support the idea of simply teaching through a lecturing process to maximize learning, although lecturing dominated the educational pedagogy during his lifetime (Liszka, 2013). Since the early 2000s, active learning theory has entered educational studies based on applications of technology, as seen in this study (Adewale, Ibam, & Alese, 2012; Gulwani, 2014; Lerman, 2012).

Peirce began his journey into active learning during his teaching time at John Hopkins University by developing a correspondence course, *The Art of Reasoning*. The syllabus for the course included a statement citing that the purpose of education is to teach students how to do something. This simple statement formed the basis for a profound departure from traditional education methods. This statement began the journey into active learning where the student actively engages in the content to be able to apply to the real world what he or she learned in the classroom (Peirce, 1982, V6, p. 11). Jastrow (1916), one of Pierce's students, remarked that the use of discovery made Peirce an excellent teacher. Peirce did not simply lecture material and assign work for the students to complete later. Instead, he advocated learning by doing, which also comprised the core of his pragmatic maxim. Pierce guided students through a pattern of discovery to arrive at new concepts and ideas. These discoveries made the concepts more memorable and lent to discussion on application (Liszka, 2013). Hull (2008) noted that a student easily forgets information unless it is learned by doing or while doing. This same idea presents itself clearly in the writings of Peirce as his students describe their learning process in his courses. The use of discovery in the classroom, as Jastrow (1916) described Peirce's teachings, comprises a key instructional strategy for active learning. In addition to hands-on learning, students should have real engagement between the theory and practice to make meaningful connections between the classroom and the real world.

Drew and Mackie (2011) discussed that learning through play commonly defines active learning theory in the educational world; however, as the authors pointed out, active learning should encourage participation and promote logical and creative thinking while encouraging problem-solving approaches. Therefore, learning through play and social interaction is not the only application of the theory in the classroom. While learning through play certainly applies to lower levels of education, one would not expect to see secondary students engaging in play during class. Active learning situations should also provide a range of skills that make learners think and interact with the problem. This can be accomplished through hands-on learning and technology in the secondary classroom. While several articles exist on the use of mathematics and technology (Demir & Basol, 2014; De Witte et al., 2014; Vilardi & Rice, 2014), only Wilder and Berry (2016) examined the use of technology to enhance the classroom through the lens of active learning.

Other discussions on modern-day interpretations of active learning include Gulwani (2014), who advocated for example-based learning in STEM education to automate repetitive tasks in Algebra I and Geometry. By providing examples that create a pattern, students can learn by discovery as seen in Peirce's writings. To move this to modern-day applications, the use of programmable software can automate ideas including structured tasks, problem generation, solution generation, and feedback. Programmable software allows for large numbers of variations in problems generated and can automate feedback for mistakes based on answers given. It also produces numerous examples for students to view and learn from. In addition, the use of this software allows students to learn by doing and discovering repeated patterns in problems that can be applied in mathematical procedures. Gulwani explained that example-based learning stems from active learning in that students discover patterns through conceptual problems and then perform reasoning to abstract the relationship. In essence, students learn by doing and by using technology.

This study used the premise of student-centered learning through inquiry to guide the use of Math XL and apply active learning theory. As discussed by Gulwani (2014), this software can be used to automate tasks that are repetitive in Algebra I and Geometry, such as solving equations, identifying transformations, completing simple proofs, and more. Liszka (2013) described active learning theory as student-centered engagement with the subject matter. The purpose of the present study was to examine the engagement in the Math XL software with targeted assignments to determine whether there was a statistically significant difference in achievement on the EOC tests in Algebra I and Geometry. This supports the theory suggested by Gulwani (2014) and aligns with Peirce's writings on active learning theory with a technology application. Math XL was used as computer-assisted mathematics education for students enrolled in the intervention program to provide interaction between the software and the student with guided input from the teacher. Students engaged with guided inquiry and utilized the tools in the software such as *Help Me Solve This* and *View an Example* to identify patterns in the concepts and learned while doing problems.

The *Help Me Solve This* tool walks students through a problem step-by-step while allowing students to enter their solution for each step. The program then checks their answer and lets them know if an error is found. This allows students to pinpoint where misconceptions occur in the concept. In *View an Example*, the software works out a problem showing the student one step at a time. In this tool, students do not interact with the software other than to signal when to show them the next step. Therefore, students learn through working the problems with the tools and can automate basic mathematic concepts. Students also apply abstract concepts to concrete problems as they progress through the problems in the software. Ideas such as performing the opposite operation to isolate a variable are concretely practiced many times to allow the student to engage with the material and, therefore, apply the abstract idea of isolating a variable to solving an equation (De Witte et al., 2014; Kodippili & Senaratne, 2008). Students engage in active learning through doing teacher-selected problems in the software and apply what they have learned to new abstract mathematical contents (Gulwani, 2014). This extends the realm of active learning into the use of computer-assisted learning programs for students to increase mathematics achievement.

Related Literature

In 1997, Florida revolutionized education by starting the first fully online public high school in the United States. Until this point, distance education consisted of correspondence courses or televised courses. The only school choices available before 1997 were homeschooling or a brick-and-mortar school. When Florida created the first online school, it allowed for an unprecedented third choice for families. Since then, other states have started their own online programs, and enrollment in online courses has steadily increased in K-12 schools. School systems even offer online programs at the district level for homebound students or students who have surpassed the typical age for their grade. Parents opt for their children to attend online programs for many reasons (e.g., individualization of education, daily progress reports, special education needs, emotional needs). The idea of school choice allows parents to make a personal decision for their child on the best method of schooling, as well as the best school. While growth continues in online education, many parents are not fully prepared for what is required in online learning and lack the ability to maintain structure in flexible programs.

While online learning has many proponents, many criticisms and myths also exist (Kim, Kim & Karimi, 2012).

Online or virtual schools continue to attract more students with learning differences than their brick-and-mortar counterparts do (Thompson, Ferdig, & Black, 2012). As mentioned earlier, this could be for more individualized education, more connection with a disabled student's learning for a parent, or to manage behavioral issues. It is important to note when examining the traditional brick-and-mortar schools, the estimated success rate of students in a standard math curriculum is only 80% (Kuo, 2014). Thompson et al. (2012) indicated that the number of students in an online school with special education needs outnumbers those in the traditional public school environment. This means that online schools have an additional strain on the academic performance side of accountability, as more students require additional help to succeed and reach grade-level expectations due to a larger population of students with exceptionalities than their brick-and-mortar counterparts. However, accountability exceptions are not made based on the higher population of students who require extra assistance in accessing the mainstream curriculum.

Per a federal mandate, all schools must identify students who need intervention to address those students who are not reaching grade-level expectations, regardless of the school setting. This includes the 20% of students who are not successful in the standard math curriculum at a traditional school and a greater percentage of those in an online school due to the unique population that has a higher concentration of exceptional students (Antrim & Robins, 2013). The present study included an examination of the use of computer-assisted learning programs as an intervention strategy for Level II RTI to observe the impact on mathematics achievement as measured by the EOC tests in Algebra I and Geometry. The use of the computer-assisted learning programs fully addressed the RTI guidelines as given in federal legislation to reach the students who were not achieving grade-level expectations in Algebra I or Geometry. Further, the culture of online K-12 schools through the lens of how they respond to students who are not reaching grade-level achievement in math by utilizing computer-assisted learning as a form of active learning in the online classroom was examined in the related literature section. Active learning presents differently in the online classroom, as teachers are not face-to-face with students during instructional time. The use of Math XL as a computer-assisted learning program allows for quality interaction and student-centered learning from the home as typically seen in an online environment.

History of Online Secondary Schools

Kokko, Pesonen, Kontu, and Pirttimaa (2015) defined online learning as when a student studies exclusively using the Internet without using a school building for learning or meetings. This definition excludes many hybrid or blended learning programs where students attend a center for parts of the week. In this definition of online school, students can choose the time of day they complete the lessons and the location where they do their schoolwork because learning is mostly asynchronous. However, this does not mean that synchronous sessions with a teacher are not included. The synchronous requirements vary from program to program but still allow for ample flexibility for families on school times and locations. Online learning has also begun to be linked to the term *virtual learning*. Elementary and secondary virtual schools or online schools in the United States are just reaching the 20-year mark of existence following the lead of Florida Virtual School (Kim et al., 2012). According to the U.S. Department of Education (2010), virtual learning has replaced previous types of distance learning, such as correspondence courses, educational television, and teleconferencing. According to Corry (2016), two options exist for virtual schooling—fully online and blended. In a fully online school, the student completes the entire program online. In the blended environment, the student attends some coursework at a location and completes the rest online. This study examined a school with a fully online program design. Waters, Barbour, and Menchaca (2014) estimated that in 2016 there would be roughly 4.8 million virtual and cyber online students in the United States in K-12 education. With the gains of students in virtual education, there are concerns regarding accountability issues such as grades and dropout rate.

Accountability

According to Teo and Osborne (2014), accountability in education is a social practice through which distinctive relationships are identified, and evaluative procedures are employed to measure the performance of a school or teacher. Mathematics teachers feel more pressure than other disciplines outside of English to deliver high test scores to secure a positive accountability score. In part, this is due to a results-driven culture that stems from federal and state education pushes for a results-driven approach to increase accountability scores at the state level. Due in large part to the push for results-driven education, interventions are increasingly prevalent to identify potential issues early on and to remediate skills. In England, the idea of school performance came into existence to aide in school choice for families as a part of the 1992 conservative government's agenda (Perryman, Ball, Maguire, & Braun, 2011). Many online schools fall under the category of charter schools, and like schools in other countries, score metrics are in place to guide parents on deciding the best option for their child (School Choice, 2017).

Louisiana has put into place numerous categories that add together to produce a school performance score (SPS). According to the LDOE, for the 2016-2017 academic year, there were several categories used to calculate the SPS, including the strength of the diploma, advanced coursework, standardized testing, graduation index, and progress points (LDOE, 2017b). The graduation index or strength of diploma is calculated from the number of students graduating with a diploma and holding college credits through either the CLEP program or the AP program. The index was further strengthened by the number of profoundly disabled students who achieved a state diploma through the Leap Alternative Assessment (Laa1) program, where alternate graduate assessments are given to students. The graduation index is calculated by the number of four-year graduates from a school, with penalties for students who do not pass their senior year or choose to drop out. Standardized testing is calculated from grades 3-12. For elementary education (3-8), the Louisiana Educational Assessment Program (LEAP) test is used, and students who score proficient or above are counted toward the school score. For high school, the EOC tests for identified subjects are counted, but only if students achieved a score of *good* or *excellent*. Students scoring *needs improvement* or *fair* did not earn points toward the SPS. At the high school level, ACT scores were also used to earn points toward a SPS score. Students who earned a passing score on an advanced placement test or CLEP test also added points to the SPS in that category, as well as under strength of diploma. These scores are calculated each year and released to the public for all public and charter schools sometime in October on the LDOE website. This is meant to be a tool for families to use appropriate school choice in the various programs in Louisiana, including tax-funded vouchers for private schools, charter schools, and traditional district-level brick-and-mortar schools. For the 2016-2017 school year, one online charter earned an SPS grade of C and two other online charters in Louisiana earned SPS grades of D (LDOE, 2017a). The schools showed significant dips in the graduation index due to large numbers of dropouts or students not graduating on time, as well as low standardized test scores.

As attendance and tests are challenged in the state legislature, it should be noted that these online schools have unique challenges with getting students to show up for testing and in tracking truancy. An employee of one of the online charter schools and an SPS-trained member of their staff pointed out that for each student who does not show, the school receives a zero in the SPS score (M. Caillet, personal communication, September 27, 2017). Caillet also pointed out that online schools lack a public transportation system and, in high-poverty areas, the schools encounter many issues in getting students to test sites (personal communication, September 27, 2017). Accountability remains an issue in the Louisiana school system, as the state tries to determine how to quantify the SPS scores for the online schools.

Online charters are not alone in difficulties with accountability measurements. Teo and Osborne (2014) conducted a study on accountability measures in a STEM charter school. In this study, it was argued that there must be clarity for how performance is measured and achieved. This was due to some decisions at the school level negatively impacting the accountability measures without that being the intended result. Allowing students to withdraw from the school without providing a new school is one example of an indirect impact on accountability measures. Furthermore, professional accountability at STEM schools presented a challenge. Many teachers in the study held advanced degrees in science and math, but lacked experience in educational pedagogy or an understanding of standardized testing outcomes. These are a few examples of challenges that exist in other types of schools in reference to accountability. As seen in this study, one size does not fit all in accountability.

Corry (2016) completed a study on the dropout rate of Hispanic students in Arizona in online-blended, online-only, and public schools. The study found that the dropout rate in blended programs was lower than those in online-only programs. The U.S. Department of

Education (2010) published a report that noted the lack of experimental or quasi-experimental studies conducted in online schools. According to the report, there is little empirical data to support or oppose online-only education. The study also found that students in online-only programs performed moderately better than students taking part in traditional face-to-face courses. However, this is only one small segment of the online school population in the United States. Accountability also raises concerns for how to measure performance in online schools with their diverse student population that consists of a higher population of students who require additional services to be successful in the academic arena. Additionally, challenges exist that are unique to online schools when determining a SPS that does not exist in traditional brick-and-mortar schools (Thompson et al., 2012).

Special Education in Online Schools

Several studies demonstrated that online schools do not perform at the same level as their counterparts; however, when there is no control for the social, emotional, or health issues of students, the online schools perform admirably compared to the traditional learning environment (CREDO, 2015; Glass & Welner, 2011; Hubbard & Mitchell, 2011). This means that when populations of students with learning differences are compared in a virtual setting versus a traditional setting, they perform at the same level or higher in a virtual setting. As a counterexample to these studies, when Carpenter, Kafer, Reeser, and Shafer (2015) used a matched sample between the schools to control for inconsistencies in the population of students, they found the differences were not all significant between online schools and traditional schools. The conclusions suggested that online schools offer a diploma that is an equivalent education for those who have health challenges. Due to health challenges, many students cannot attend a traditional school for a full day, which hurts their academic performance. However, an online program allows them to attend at any point in the day and have greater instructional exposure. The conclusion of this study shows that the strength of the online diploma is about the same as the brick-and-mortar for this specific population. Having a larger population of students with emotional, social, health, or behavioral issues can create additional challenges for online schools to demonstrate adequate academic growth, but this study provides a counterexample.

Coy and Hirschmann (2014) suggested that the lack of parental involvement in day-to-day activities in public schools could cause parents to seek an online program, which would explain the larger population of special education students. Coy and Hirschmann further suggested that parents of students with exceptionalities would prefer increased involvement in all aspects of their child's education. In an online environment, parents can closely monitor curriculum and grades and assist their children in ways that are not possible in traditional schools. In addition, they also cite easier access to therapy sessions or medical appointments, which is yet another reason for seeking an online program versus a standard brick-and-mortar school. Many appointments occur during the day, which becomes a challenge in a traditional school. Even when services are provided by the school system, additional private therapy may be needed. Furthermore, students with exceptionalities who also have health issues miss school for medical check-ups, which also takes away from instructional time in the school. While parents are involved in individual education plan meetings, progress reports, and conferences at a traditional school. They lack the daily interactions with their children and seeing the challenges in real time. Parents see grades after units are complete and often cannot judge whether students are struggling until a large portion of material has been covered in a traditional school setting. Due to the larger population of learning disabilities, intervention programs play a vital role in the online learning environment.

CREDO (2015) found that online schools reduced the impact of student achievement on special education students when compared to nonspecial education students. Special education students have unique challenges in the classroom with access to the general curriculum, as well as equitable instructional time due to various therapies or appointments that they must attend. Thus, the lower student achievement scores showed a skewed effect in the online setting, which resulted from the larger population of special education students and subsequent lower achievement scores from more profound exceptionalities that have chosen online school. Specifically, the study found that math academic growth in online charter schools was significantly less negative than that of nonspecial education students. Online charter schools showed progress in aiding the special education population to increase academic achievement, specifically in mathematics. Increased instructional time, interventions, and strong support in the home aided students with exceptionalities in their academic achievement in the online environment. Results varied for average students with nonspecial education backgrounds in the study, depending on the state. This shows variation in the programs between students with exceptionalities and their neuro-typical counterparts and the need for further study to determine the source of the differences.

Domestic Math Achievement

Online schools are not alone in their struggles with academic achievement. More to the point for this study, online schools and traditional schools are struggling with mathematics achievement in the United States, where mathematics education has remained stagnant from 1971 to 2012. During this period, there was little to no growth in math achievement among 17-year-old students (NCES, 2015a), and online schools were not an option during most of this era. Therefore, these results reflect performance of students in traditional schools and illustrates that the challenge of achievement is faced by all and not just charter or online schools. Students in U.S. schools remain at a disadvantage when it comes to higher education mathematics due to a lack of preparation for math on the secondary level. A large gap exists between the actual level of math achievement of students and the desired level of math achievement to enter into postsecondary education. Significant concerns are presented regarding students' preparation for higher levels of mathematics when leaving the secondary education system.

Furthermore, state standards demonstrated a lower level of proficiency that more closely aligned with a community college level than the national standards set to reflect a four-year university route. This shows that gaps in achievement exist, as well as gaps in state-level expectations (Lee, 2012). Larger online schools use national standards, as many have a nationwide parent company. An example of a nationwide standard system includes the use of Common Core standards, which benefit the student population, as seen in a study conducted by Lee (2012). Online state-level schools adjust the nationwide standards due to their parent companies and prepare students for higher education despite the geographic location of the high school or college. A student in Mississippi receives the same level of education as a student in California with this design.

The National Assessment of Educational Progress (NAEP) performed the largest ongoing assessment of what American students know and can perform in core subjects. The assessment is also nationally representative of the population. On a national assessment, the program has between 10,000 and 20,000 participants from schools all over the nation (NECS, 2016a). In 2016, the NAEP released *The Nation's Report Card* following the 2015 assessment and found that scores went down from 2013 to 2015. In 2005, 2013, and 2015, 12th-grade students were assessed in mathematics under the current mathematics framework. The scores in 2015 were significantly different from the scores in 2013. The scores in 2015 showed that middle- and lower-performing students decreased significantly in performance from 2013. In 2015, the average was 152 on a scale of 0-300; in 2013, the average score was 153. To see the full picture for the results of the NAEP math assessment, the results in 2005 should also be examined. The 2015 score did not vary significantly from the initial 2005 average score (NCES, 2016a). This shows that even the most recent efforts to improve math education fall short of the goal of improving domestic mathematics achievement.

In later testing in 2017 and 2019 there was not data on 12^{th} grade students but there were significant findings for 8^{th} grade mathematics students. In 2017 there was no significant change in the scaled score for the average mathematics score for 8^{th} grade students with the score being a 283. The change in the average score for 8^{th} graders in mathematics was an increase of one point on the scaled score, which was found to not be significant. When compared other years the average remained within 4 points from 2007 with some years being just above and some years below. This further shows that efforts to change the mathematics achievement through various curriculum changes, standards revisions and instructional practices have not been successful. What is of significant concern from the 2017 scores is that the gap between lower achieving students and higher achieving students has widened. Students in the lower percentiles (10^{th} to 25^{th}) scored a lower average score by 2 points. On the other hand, higher achieving students increased their average score by 2 points. The result is a widening gap for 8^{th} grade students that would be eligible for RTI services. The implications of this show us that current RTI efforts are not enough for lower performing students (NCES, 2018).

Examining the 2019 scores showed that the non-significant point gained by 8^{th} grade mathematic students was lost decreasing the scaled score average back to a 282. While the gain in 2017 was not seen as significant the drop by one point is seen as significant. This could be from looking at the comparison over time. In 2013 the scaled score was a 285 which then dropped to a 282 in 2015. Then in 2017 and 2019 the mathematic performance score fluctuated, dipping down and then up. However, it did stabilize back at a scaled score of 282, which is even with the 2013 scaled score. This shows that there is a significant need to examine the key changes overall for 8th graders to better prepare them for secondary and post-secondary instruction. Another significant feature of the results from 2019 are the lack of growth or regression by percentile. Students in the bottom 10th percentile fell by 2 points in their average scale score. This means that from 2015 to 2019 the bottom 10th percentile fell by a total of 4 points on the average scaled score. The lower 25th percentile, the 50th percentile and the 75th percentile all saw statistically significant drops of one point on the averaged scaled score while the top 90th percentile stayed the same. This shows no growth over the two-year span from 2017 to 2019 and losses at the lower level (NCES,2020). This shows a stark forecast for secondary and post-secondary education as mathematic achievement even at the highest level is stagnant while the students that most need RTI and support continue to lose ground in mathematics. This supports the case for further investigation of new practices to help all students be successful in mathematics so that students are prepared for high school. When students are not prepared or on level for high school this impacts their ability to get post-secondary education or even trade school.

The PISA test results from 2003 to the most recent 2018 examination further support the need for domestic mathematic education reform. The scores from 2003 to 2018 have declined. In 2003 the average for mathematics was 483. From this value it fluctuates to 474 in 2006, 487 in 2009, 481 in 2012, 470 in 2015 and 478 in 2018. This fluctuation has still not returned to higher gains seen in 2009 and according to the OECD, demonstrates that there has been no significant improvement in the United States scores when compared to each other. Instead, the OECD states that the achievement remains about the same in mathematics (OECD, 2019). Even this snapshot of the United States performance on an international test demonstrates the stagnate state of mathematics achievement in the United States despite efforts at reform.

International Comparison of Math Achievement

In addition to a domestic gap, the United States continues to lose ground internationally in math (Lee, 2012; NCES, 2015a; OECD, 2013). Every three years, the OECD cooperates with the PISA to assess student learning in reading, mathematics, and science. The test assesses mathematical literacy through formulating situations mathematically; employing mathematical concepts, facts, reasoning, and procedures; and interpreting, applying, and evaluating mathematical outcomes. In 2012, over 6,000 U.S. students from 161 schools participated in the PISA test. During this time, the United States lost ground from the 2006 PISA test and continued to perform well below the average of other nations. Only 2% of students in the United States reached the highest level of performance (level six) on the 2012 PISA test. The OECD average was 3%, and top nations ranged up to 31% reaching the highest level. This demonstrates the need for change in the U.S. secondary system of mathematics and shows that concerns remain, whether the student was enrolled in online or traditional schools, regarding preparedness for the job market and postsecondary education (OECD, 2013). A clear gap in math remains in the educational system with students requiring additional resources to access the standard math curriculum (Gresham & Little, 2012; Kuo, 2014), and even more resources are needed to be internationally competitive and ready for postsecondary education (Lee, 2012; OECD, 2013).

The results from the 2018 PISA test are even more telling. The United States performed below the international average for the mathematics portion of the PISA. It should be noted that in the Unites States there was no criteria for selecting students that would participate and other countries may employ gate keeping mechanisms. One way to view this is through the achievement of basic levels within the test. Level 2 attainment indicates that students can interpret and recognize without instructions how a situation can be represented mathematically. This includes translating basic word problems with currency or distance as a focus into a mathematical expression. In the United States 73% of students reached level 2, however, the OECD average was 76%. To put this into context countries like Singapore had 93% attain mastery of level 2 while the Dominican Republic had only 9% at this level. The OECD average accounts for these outlier scores and may not be the best mean representation. If this is investigated further to find meaningful conclusions, the higher levels can be used. At the higher levels the range is smaller with fewer outliers. Level 5 for instance means that students have reached the benchmark where they can model complex situations with math and can evaluate and use critical thinking skills to solve them. Only 8% of students in the United States that took the PISA attained this level. The OECD average was 13% with Asian countries scoring much higher. China had 44% attain mastery of Level 5 while Singapore had 37%, Hong Kong 29% and Korea 21%. All of these numbers are much higher than the United States percent. This shows the continued international gap in mathematics as the United States remains below the average in mathematics and in many areas by level far below the average (OECD, 2019).

In addition to the PISA test, the Trends in International Mathematics and Science Study (TIMSS) examines international achievement in mathematics and completes a comparison study at the international level. The TIMSS is given internationally to 4th- and 8th-grade students

(NCES, 2016b). The assessment was developed by the International Association for the Evaluation of Educational Achievement (IEA), which is comprised of national research-based institutions, as well as governmental research agencies (NCES, 2015a). The TIMSS assessment is given every four years to countries that elect to be a part of the study. In the United States alone, between 182 and 250 schools have participated in the TIMSS assessment from 1995 to 2015. Participants ranged from 7,296 to 12,569 at the 4th- and 8th-grade levels (NCES, 2016b). The number of countries that participate varies from year to year, with 29 participating in the 1995 administration for 4th grade and 46 participating in 8th grade in the same year. In 2015, 49 countries participated at the 4th-grade level, and 38 participated at the 8th-grade level.

In the 2015 administration of the TIMSS assessment, the United States ranked higher than 34 education systems and lower than 10 education systems at the 4th-grade level. At the 8th-grade level, the United States ranked higher than 24 systems and lower than 8 systems. However, it must be noted that the score for 8th-grade students only increased from 492 to 518 over 20 years from 1995 to 2015. This is not a statistically significant increase based on the data presented in the study. The highest score possible is 700. Therefore, 518 remains significantly lower than the optimal score. However, this does show gains being made based on the assessment, but the gains are small over a long period. While the United States performed better than the 24 systems in the most recent study, the level of growth is a concern when mathematics achievement is a global concern.

TIMSS also offers an advanced assessment for 12th-grade students. Students who take the advanced assessment have taken, or are currently taking, an advanced mathematics course. This was defined, in 2015, as those taking a second-year international baccalaureate course or an advanced placement mathematics course. The nine countries that participated in TIMSS advanced in 2015, with roughly 241 schools participating in the United States and over 2,900 students. The TIMSS scores for all countries decreased from 1995 to 2015, with the U.S. score going from 497 to 485 (NCES, 2016b).

Gender Gaps

According to the NCES (2013), there were no significant gender gaps in mathematics in the United States for ages 9 and 13 based on the 2012 assessment. This is a startling conclusion for teachers who have been in the field for many years, as the gender gap was very prevalent in previous studies. The target demographic for ninth- and tenth-grade students is around 14 years of age; when comparing this to the given ages from the NCES, the students fall between the 13- and 17-year-old age range. At the age of 17, the gender gap is only 4 points, which is a statistically significant difference from the 8-point gap in the 1970s. The gender gap is closing in U.S. STEM education. The NCES (2013) used data from the NAEP to track student performance at the ages of 9, 13, and 17 to investigate long-term trends. Arslan, Canlt, and Sabo (2012) further supported this claim by showing that there was no statistically significant difference between males and females in sixth through eighth grade in mathematics achievement scores; however, they did find that attitude scores toward mathematics differed greatly between genders. The authors concluded that females should be encouraged to pursue mathematics education, as they have the ability, but as seen in the study, have less confidence regarding their performance.

To further support this the OECD examined performance by gender in the 2018 PISA results. Males only performed 9 points higher than females which was found to not be statistically significant. An interesting find was that there was a reading gap by 24 points between the two genders. Even though historically the gender gap is more traditionally thought to exist in math or science. However, attitudes of males and females toward careers in STEM was shown to be different. While 3 in 10 boys with a strong aptitude for mathematics declared they were interested in engineering or science-based profession, only 1 in 10 girls indicated the same. While the achievement gap is not a factor in gender, attitude is a significant factor for females (OECD, 2019).

In addition, women continue to be underrepresented in bachelor's, master's, and doctoral programs in STEM fields, according to Beekman and Ober (2015). Beekman and Ober (2015) investigated the results of the NCES in their own study, which was conducted in Indiana, and confirmed that the gender gap is quite small to nonexistent, as females score comparable to males on testing for math achievement; however, they did agree that girls and young women should be encouraged to pursue STEM fields, as there will be an increasing need in the coming years for jobs in those fields. In conclusion, as gender gaps for mathematics achievement have closed over time, the present study did examine gender as a variable in comparing math achievement between those in intervention and those not in intervention.

Response to Intervention

In 2004, RTI was added to the IDEA as a different evaluation procedure for schools. The goal of the legislation included identifying early students who struggle and providing appropriate interventions while also identifying students with learning disabilities (Turse & Albrecht, 2015). Furthermore, RTI implementation across the country intends to ensure that all students receive the tools and instruction necessary to achieve grade-level or higher academic success. In general, the RTI process seeks to (a) identify students and their problem with the content, (b) create an intervention plan, (c) implement the intervention, (d) evaluate the student and his or her progress, and (e) continue to make intervention plans based on student progress (Martinez &

Young, 2011). Through these steps, RTI seeks to reach all students regardless of challenges or exceptionalities and to bring them to grade-level expectations in a given subject. The idea behind this process is that all students can learn, but some may need additional support outside of general classroom instruction. Additionally, some students may need more repetition or more dynamic teaching methods. By creating detailed plans and following up with evaluations, valuable data show student progress using intervention programs (Gresham & Little, 2012).

The first step in response to an intervention plan is identifying students. According to Burns et al. (2012), students in or below the 25th percentile are at risk in the standard classroom without additional resources. Different tiers exist in this group, based on need. Tier 1 addresses general classroom instruction given to all students. RTI classifies all students in a general education classroom as a tier 1 intervention unless they qualify for a different tier. Tier 2 specifically addresses those below the 25th percentile and includes more personalized instruction that can include small groups. Tier 3 typically includes students in the bottom 15% or those not progressing in prior levels of intervention. Tier 3 has a greater frequency of instruction and more individualized instruction than the other two tiers. It is important to note that the different tiers exist, but are not concrete, as no federal guideline exists concerning where to draw the line with students (Antrim & Robins, 2013). As seen by several authors, the key to a successful intervention is individualized or small-group instruction with rich feedback from the interventionist (Antrim & Robins, 2013; Burns et al., 2012; Gresham & Little, 2012). The present study compared a sample from a small-group intervention using Math XL to students who only received the general course instruction. RTI criteria have been applied when identifying students to take part in the math intervention program.

Computer-Assisted Learning

Computer-assisted learning integrates computers for positive results in the educational process for mathematics, where students can identify their deficiencies and performance level through mutual interaction with the software (Demir & Basol, 2014). Another similar name for this that is used by practicing educators and interventionists is a computer-based supplementary instructional support program (CSISP). Integrated with RTI theory, CSISP allows teachers to tailor instruction to students' individual needs and track progress accurately. CSISP delivers highly- and correctly-targeted instruction and practice, which allows students to gain knowledge and confidence that the knowledge gained is correct (Burns et al., 2012). Much like CSISP, computer-assisted learning can refer to software used in the general education classroom that is not specifically tailored to an intervention (Demir & Basol, 2014). Universities have studied computer-assisted learning programs and found favorable results for programs such as My Math Lab (MML), ALEKS, and more (Hu et al., 2012; Wilder & Berry, 2016; Ye & Herron, 2012). Computer-assisted learning programs also bring the focus back to the student. During a time when there is a disproportionate number of students to teachers, these programs increase the individualization of the educational process (Demir & Basol, 2014). This is especially important in schools that have a large population of students with learning disabilities or economic disadvantages (Vilardi & Rice, 2014). As stated earlier, online secondary schools attract a larger group of students with social, emotional, or health issues. This makes computer-assisted learning ideal for online schools, as the programs can target key weaknesses and give the students rich feedback (Demir & Basol, 2014).

MML and Math XL, the secondary counterparts, offer multimedia instructional videos and resources, practice exercises where students can determine how many problems to practice, homework assignments, and tests. The program allows three tries on homework and practice problems before assigning a new problem. This allows time for students to find their mistakes. Once an incorrect answer registers in the program, it gives suggestions to the student on how to obtain a correct answer (e.g., formulas, explanations). After three attempts, it shows the correct answer. Outside of a test, it allows the selection of a similar problem to try again. There are also help tools that can help a student with a problem. In the homework and study plan students can get guided steps to solve a problem using the *Help Me Solve This* button. This takes them through the problem step by step and allows them to type in their answer for each step. This allows students to find their own mistakes and will also make the mistake memorable so as to not repeat it again (Kodippili & Senaratne, 2008).

Computer-assisted instruction also allows students to organize and direct their own education and remediation of concepts. As the programs adapt to the learner, the student can realize any deficits in their learning and organize studying based on the program feedback. Benchmarks assessments are given or the computer tracks the student as they move through assignments to flag areas of improvement. This gives students a sense of ownership into their education. Additionally, more disadvantaged youths experience equal educational opportunities, which may include better opportunities than presently offered in their environment. Disadvantaged students often suffer from a lack of access to high-quality educators, strong textbooks, and other beneficial resources for their education. Due to these benefits and others, many schools opt to invest resources and funds into the computer-assisted learning programs (De Witte et al., 2014). N. Pulkein (personal communication, October 25, 2016), the head of the RTI program for a nationally-based online school with subsidiaries in many states, explained that these benefits are also why the company has chosen an entire suite of software options for math intervention from the kindergarten level through high school. A distinctive aspect of online schools includes being uniquely equipped to use computer-assisted technology in their respective learning management systems. As the students are currently online, technology does not act as a roadblock for students accessing the programs and properly interacting with them. The online school has vetted an assortment of programs to use with students and claims to see strong gains for those students who engage in the program. The program used at the secondary level is Pearson's Math XL, which is a sister program to MML (N. Pulkein, personal communication, October 25, 2016). Kodippili and Senaratne (2008) concluded that while there was no significant difference between those students who used MML and those who did not use MML regarding achievement in college algebra, there is a significantly higher percentage of grades in the A, B, and C range for those who completed the online homework. This is one of a handful of studies that used MML but are all at the university level. When asked about empirical evidence regarding the Math XL program, the director indicated that they had not been presented with evidence, but that it aligned with their textbook, as it was created by the same publisher (N. Williams, personal communication, October 25, 2016). The preceding reinforces the idea of a lack of peer-reviewed empirical data to support the use of computer-assisted learning in traditional or online classrooms. Despite the lack of evidence, a host of online secondary schools are implementing programs without empirical evidence as to which ones truly benefit students or whether the academic gains justify the steep prices. To determine true academic gains or losses, more research should be performed regarding the use of computer-assisted learning. While it may be more convenient and require fewer faculty, not much is known about the outcomes from an academic standpoint.

In addition to the lack of research at the secondary level, it should be noted that more postsecondary educational institutions use MML or a similar computer-assisted learning program for remedial or developmental math courses. The rationale behind this includes a wide variety of reasons such as self-paced instruction, lack of available faculty to teach the course, grading challenges with large student populations, and a wide variety of student educational backgrounds. At the university level, the course management system is the most utilized feature that allows the instructor to design the program course. Although some schools use a prescribed shell, other schools do allow some freedom in course design. Students can then take advantage of the various helpful tools in the software to complete assignments successfully. This is also graded quickly by importing scores and lowering the burden on teachers. This in turn allows for larger class sizes to ease financial burden on universities. Even if a student does not directly require a computer-assisted learning program for an intervention, he or she will likely encounter it in postsecondary education (Vilardi & Rice, 2014).

Summary

Math achievement continues to be an issue in domestic and international markets .Gaps are evident as early as 8th grade for students and persist through secondary mathematics education (Lee, 2012; NCES, 2013; NCES, 2015a; NCES, 2018; NCES, 2020; OECD, 2013; OECD 2019). Ultimately, this can result in a shortage of students who enter STEM fields, and companies may outsource jobs to graduates of other countries, causing a dilemma for the American education system. On a positive note, gender appears to no longer be an indicator of math achievement despite the underrepresentation of females in STEM fields (Arslan et al., 2012; Beekman & Ober, 2015; NCES, 2015a). Without graduates who specialize in STEM areas, the United States will continue to fall behind in many areas internationally (Wagner, 2008).

While online schools have not yet been proven to be academically superior or even equal to traditional schools, enrollment continues to skyrocket due to referrals from physicians, family choice, and flexibility (Carpenter et al., 2015). Accountability measures continue to present challenges for online schools to be compared to their brick-and-mortar counterparts as well as to remain in operation. Accountability in the online format has different needs since students do not physically show up each day. This presents unique challenges to getting students to complete standardized testing which forms the basis for many accountability models for states. Online schools can lose their charters if an accountability rating becomes too low. Caillet discussed the need to achieve at least a grade of C to maintain a charter without state interference in the online school design (M. Caillet, personal communication, September 27, 2017). Some online schools in Louisiana are facing potential mandates for hybrid programs due to low accountability scores, which will present additional challenges for schools to use funds responsibly. Accountability presents additional hurdles for online schools to be aware of and address.

Despite a lack of clear data on the average nonspecial education student, online schools have proven to increase the academic growth of special education students (CREDO, 2015). As these schools attract a higher population of learning-disabled students, they must examine potential RTI programs with realizable gains that can impact academic achievement. It is also important to determine the effect online education has on students who do not have exceptionalities. RTI programs are key in both populations to bring students who are underperforming up to grade-level expectations. While online schools have the unique ability to employ computer-assisted learning programs to bridge the math achievement gap, little is known about the programs offered on the 9th-12th grade level. A national organization showed the use of a computer-assisted learning program in most of its state programs; however, the head of the intervention program for the national brand could not provide empirical data. It is important that schools begin to analyze data and that researchers investigate these programs. If these programs are proven to be successful, then it could mean change in the way RTI is staffed and allow more small-group interaction to occur, as the programs would complete lesson plans based on data obtained from the student. It would also create an individualized plan for the interventionist to allow him or her to focus more on the small-group instructional time and not the reinforcement.

CHAPTER THREE: METHODS

Overview

This chapter identifies the research design, instrumentation, research questions, null hypothesis, procedures, analysis methods, and justification for each method citing relevant texts that lend credibility to the study. Also, in this chapter, detailed steps and procedures to ensure easy replication for confirmation of results are explained. The validity and reliability of the instruments are addressed through information provided from the LDOE. Last, this chapter contains an explanation of why an ANOVA was the most appropriate analysis for the study and any prerequisites to use it.

Design

A causal-comparative design was used to complete the study. Because the students opt into the math intervention program, random assignment is not possible. These treatments happened in the past, and the data are archived. This study sought to determine if there is a relationship between mathematics achievement and the use of a computer-based learning program. The goal of this study was to determine if the use of a computer-based learning program affected mathematics achievement as measured by the Louisiana EOC exam (Gall, Gall, & Borg, 2007). The study design designates mathematics achievement as measured by the EOC scores for Algebra I and Geometry as the dependent variable and enrollment in the computer-based learning program as the independent variable. Mathematics achievement, as measured by the EOC score, is determined by the score on the Algebra I and Geometry EOC tests as determined by the scale set by the LDOE (2015). Enrollment in the computer-based learning program includes students who opted into the RTI Math XL program.

Research Questions

RQ1: Is there a statistically significant difference in mathematics achievement as measured by the Louisiana EOC test between students in Algebra 1who receive computer-assisted math intervention and students who do not receive computer-assisted math intervention?

RQ2: Is there a statistically significant difference in mathematics achievement as measured by the Louisiana EOC test between students in Geometry who receive computer-assisted math intervention and students who do not receive computer-assisted math intervention?

Hypotheses

$H_0$1: There is no statistically significant difference between the Geometry EOC test scores of students enrolled in a computer-assisted math intervention program and students not enrolled in a computer-assisted math intervention program.

$H_0$2: There is no statistically significant difference between the Algebra I EOC test scores of students enrolled in a computer-assisted math intervention program and students not enrolled in a computer-assisted math intervention program.

Participants and Setting

The participants for this study were chosen from a convenience sample of Algebra I and Geometry students at Louisiana Virtual School during the 2015-2016 and 2016-2017 academic years. The school operates independently and serves approximately 2,100 students in grades K-12 in Louisiana. Of the student population, 74% were Caucasian, 14% were African American, 4.5% were Hispanic, and 7.5% were classified as other. Additionally, 53% of students were eligible for free or reduced lunch, which was 20% lower than the state average. This population was examined because the school used the Math XL software as a computer-assisted math intervention tool.

For this study, there were 100 participants sampled for Geometry with $n = 50$ receiving the treatment and $n = 50$ in the control group. Additionally, there were 100 participants sampled for Algebra I with $n = 50$ receiving the treatment and $n = 50$ in the control group. According to Gall et al. (2007), the minimum number of participants needed for a medium effect size at an alpha level of 0.05 and statistical power of 0.7 is 100. The raw data had 72 Geometry students enrolled in intervention and 82 students not enrolled in intervention who met the grade criteria. For Algebra I, the raw data had 68 Algebra I students enrolled in computer-assisted intervention and 74 students not enrolled in computer-assisted intervention. With the raw data sets themselves varying from 68 participants to 82, choosing 50 from each group allowed for random selection, which increased the rigor of the analysis. Therefore, from the file, 50 participants for each group were selected randomly using SPSS to be a part of the analysis for this study. Therefore, the Geometry sample had 100 participants and the Algebra I sample had 100 participants.

All students in Algebra I or Geometry classes were eligible for intervention if they thought they needed additional assistance in math; however, the focus was on students with a grade of C or lower in the course, and those students were actively recruited. Students were actively recruited through contacts attempted by their math classroom teachers as well as contacts from the interventionist. Families were also invited to information sessions on the computer-assisted math intervention program if their student had a C average or lower. Therefore, the sample for the treatment had a lower average than the control group of students enrolled in the course, but not in the intervention program. Students that had lower grades in the math courses made up the intervention group and therefore lowered the overall average when compared to the non-intervention group. To control for this, the sample for the nontreatment group was restricted to students with a grade of C or below who were eligible for intervention but did not choose to enroll. Random selection added additional rigor to the analysis.

Instrumentation

One instrument was used for each analysis conducted. The Algebra I EOC test score for the Algebra I analysis and the Geometry EOC test score for the Geometry analysis were used. These EOC tests intend to measure math achievement in the course (LDOE, 2015). Due to the virtual nature of the school studied, students complete the EOC tests on computers at sites located throughout the state of Louisiana. Sites were selected to have private quiet areas where students could complete the test as well as spacing adequate for testing requirements. Sites included public libraries, private schools, universities with empty classrooms for the testing window or other facilities that could be set up like a classroom. The EOC tests did not have a time restriction for either subject. The EOC tests were completed on computers for all sections given. Students had access to a WIFI hot spot to connect to the server to take the exam. The exam did allow for equations to be entered with the computer design and had a built-in calculator for students to use. For students to graduate, proficiency on either the Algebra I or Geometry EOC test must be demonstrated by a score of *fair*, *good*, or *excellent*. The EOC tests have 3 sections: 25 multiple-choice questions (no calculator), 2 multiple-choice constructed response questions (calculator allowed), and 25 multiple-choice questions (calculator allowed). Students could score between 600-800 points. The scale for the Algebra I EOC test was defined as follows: 600-667 *needs improvement*; 668-699 *fair*; 700-738 *good*; and 739-800 *excellent*. The scale for the Geometry EOC test was defined as follows: 600-664 *needs improvement*; 665-669 *fair*; 700-730 *good*; and 731-800 *excellent* (LDOE, 2015). Other studies have used EOC tests as an instrument, which lends credibility to its use in this study (Brazelton, 2012; Clark, Scafidi, &

Swinton, 2011).

A testing company creates the test each year for the LDOE. Committees of teachers then validate questions as appropriate to meet the standards of the test. There are nine different versions of the Algebra I EOC test and seven different forms for the Geometry EOC test. The reliability statistics provided by the LDOE included a Cronbach's alpha that ranges from .84 to .87 for the 9 forms of the Algebra I EOC test. The reliability statistics provided for the Geometry EOC test include a Cronbach's alpha that ranges from .85 to .87 for the 7 different forms (D. Hopkins, personal communication, March 3, 2016). According to Warner (2013), this shows an excellent level of reliability for the Algebra I EOC test.

Procedures

Before beginning this study, approval was obtained from the IRB. After IRB approval, the principal was contacted via email to set up a meeting to discuss the study. As the school does not reside in a district, no higher permission was required, as EOC test records were the property of the school and available only to school personnel. Upon receipt of written permission from the principal, a meeting was scheduled to give the principal information about the study. At the end of the 2016-2017 academic year, the two content teachers were contacted and asked to participate by providing a list of students in their courses with a final grade of C or below who did not participate in an intervention during the 2015-2016 and the 2016-2017 academic years. There was one Algebra I teacher and one Geometry teacher in the school. Next, the teachers entered this information into a spreadsheet, assigning students ID numbers and including their EOC scores on the spreadsheet. This list was completed with a number assignment so that names were not involved in the data and student identity was protected. According to school policy, these data are kept monthly in the online system and can be retrieved by the content teacher and copied and pasted into the spreadsheet to send to the researcher. The math intervention program released archived data on participants in the program for the Algebra I and Geometry courses. The archived data include the student grade level, EOC test score, and final course grade. To protect student identity, a content teacher removed names and used a number for each intervention student to identify them, as this researcher was the interventionist at the school. The teacher used the last two digits of the student ID number. The EOC test was given the first week of May. Thus, students who dropped out were not included in the final data due to the lack of an EOC test score. Final data for the 2016-2017 academic year for the intervention program was entered by the Algebra I content teacher who also served as the department's EOC coordinator—this preserved the integrity of the data. Once this researcher received the required spreadsheets, the data were combined into two groups in SPSS: the control group (nonintervention) and the experimental group (intervention) for each subject level. Then, SPSS completed a random selection to select $n = 50$ students for the Algebra I intervention group and $n = 50$ for the Algebra I nonintervention group. Then, SPSS also completed the random selection of $n = 50$ for the Geometry intervention group and $n = 50$ for the nonintervention group and conducted the analyses.

In the math intervention program, the interventionist assigned six daily problems for students to complete in Math XL, choosing problems based on the objectives covered in the daily lesson, as well as the type of problems in the quizzes, tests, projects, and EOC preparation materials. The interventionist used the objectives for each daily lesson and the daily quiz to select the appropriate problems. The students interacted with the Math XL program and utilized tools, including *Show Me an Example* and *Help Me Solve This,* to gain an understanding of the problems. Students were allowed unlimited attempts to get the problems right and could contact the interventionist for help, if necessary. This researcher applied this treatment to the students in the 2015-2016 and 2016-2017 academic years.

Data Analysis

To analyze whether there was a significant difference in the means of the EOC test scores between students enrolled in a computer-assisted math intervention program and students not enrolled in a computer-assisted math intervention program, an ANOVA test was completed for each hypothesis. An ANOVA was the most appropriate analysis, as the independent variable, enrollment in intervention, was categorical and the dependent variable EOC score was interval level (Warner, 2013).

Before conducting an ANOVA, data screening must be conducted and assumptions tested. First, the data was checked for correctness or missing values. Then, a box-and-whisker plot was used to identify extreme outliers in the dataset. Once the data was screened and determined to be error-free, the assumptions required for an ANOVA were tested.

For the ANOVA statistic, several assumptions must be held tenable (Warner, 2013). The first assumption was the assumption of normality. To determine if the assumption of normality was met, a Shapiro-Wilk test was conducted in SPSS due to sample sizes of 50 for each group. The second assumption for ANOVA was the assumption of homogeneity of variances. The Levene's test for equality of variances was used to test the assumption of homogeneity of variances. Additional assumptions of an interval level dependent variable and independent observations already have been met. One EOC test score did not influence another in the sample group.

A significance value of $p < .05$ was to be used as the standard for accepting or rejecting the null hypotheses. The effect size was report using the eta squared statistic which was interpreted in terms of Cohen's *d* (Warner, 2013).

CHAPTER FOUR: FINDINGS

Overview

This chapter presents the analysis for both research questions by including descriptive data, completing data screening and assumption testing, and providing the results of the ANOVA analyses.

Research Questions

RQ1: Is there a statistically significant difference in mathematics achievement as measured by the Louisiana EOC test between students in Algebra 1 who receive computer-assisted math intervention and students who do not receive computer-assisted math intervention?

RQ2: Is there a statistically significant difference in mathematics achievement as measured by the Louisiana EOC test between students in Geometry who receive computer-assisted math intervention and students who do not receive computer-assisted math intervention?

$H_0$1: There is no statistically significant difference between the Geometry EOC test scores of students enrolled in a computer-assisted math intervention program and students not enrolled in a computer-assisted math intervention program.

$H_0$2: There is no statistically significant difference between the Algebra I EOC test scores of students enrolled in a computer-assisted math intervention program and students not enrolled in a computer-assisted math intervention program.

Descriptive Statistics

The archival data in the study was derived from the use of results on the EOC test and grades in the Geometry and Algebra I course for students enrolled during the years 2015-2016 or 2016-2017 at a Louisiana virtual school. The data was obtained from the content teachers disclosing only the student ID number along with the course grade and the score on the EOC test for Geometry. The raw data included 72 Geometry students utilizing computer-assisted intervention, and 82 students not utilizing computer-assisted intervention who met the grade criteria. The raw data included 68 Algebra I students utilizing computer-assisted intervention, and 74 students not enrolled in computer-assisted intervention. Of those not enrolled in a computer-assisted program, only those with a C or lower were considered in this study. This is due to the trigger for an invitation to the computer-assisted intervention being a C grade at any point in the first nine weeks of the course. All students in Algebra I or Geometry were able to request to be added to the intervention, however, only students with a C or below were actively recruited. If a student had a grade of C or below during the first nine weeks their math teacher reached out to the family to suggest enrolling in the computer-assisted intervention. In addition, after the teacher reached out to the families the teacher for the computer-assisted intervention also reached out to give information on the program and the additional support the student could receive. This targeted process resulted in a treatment group that had a lower average than the control group for the study. To keep the groups similar for comparison, only students with a C or below were included in the control group of students who did not take the intervention class. The data were also separated into groups for each subject, showing whether the student voluntarily enrolled in the computer-assisted intervention or if he or she was not enrolled. After that students were removed from the data set that had higher than a C average to keep the group. This brought the averages closer and controlled for outside influences such as a stronger foundation in the math courses prior to those in the study.

In this study, random assignment was not possible for the treatment and control groups as the students self-opted into the computer-assisted math program. Because the majority of students in the data set did not receive computer assisted intervention, a random selection of student data assisted with creating equal data sets for comparison. Before determining the appropriate sample size, a power analysis was conducted to ensure that the probability that a statistically significant difference would be detected if present. According to Gall (2007) the sample size required for a medium effect size and a statistical power of 0.70 is 100. To achieve a total of 100 in the sample, data from 50 participants was randomly selected from each group, computer-assisted intervention and non-computer-assisted intervention. With the raw data sets themselves varying from 68 participants to 82, choosing 50 allowed for random selection which increased the rigor of the analysis (Gall et al., 2007).

Geometry

Scores for the Geometry EOC test for students enrolled in the computer-assisted intervention ranged from a low score of 634, which equates to *needs improvement,* to a 758, which equates to *excellent*. Scores for the Geometry EOC test for students not enrolled in the computer-assisted intervention ranged from a low score of 630, which equates to *needs improvement,* to a 771, which equates to *excellent* (LDOE, 2015). The majority of the scores fell between a 697 to a 729 for students not enrolled in computer-assisted intervention. This correlates to *fair* (665-699) or *good* (700-730). The majority of scores for students enrolled in computer-assisted intervention fell between a 664 and a 696. This put the majority scoring *needs improvement* (600-667) or *fair* (668-699). The distribution of the data is shown in Table 1 and the mean and standard deviation for the Geometry EOC score are given in Table 2.

Table 1

Composition of Geometry by EOC Scores

Score	No Intervention	Intervention	Total
630-663	10	9	19
664-696	15	20	35
697-729	18	12	30
730-762	6	9	15
763-795	1	0	1

Table 2

Descriptive Statistics for Geometry EOC Scores

Group	*N*	*M*	*SD*
Computer-assisted intervention	50	692.66	34.25
Non computer-assisted intervention	50	695.52	34.42

Algebra

Scores for the Algebra I EOC test for students in the computer-assisted intervention ranged from a low score of 634, which equates to *needs improvement,* to a 732, which equates to *excellent*. Scores for the Algebra I EOC test for students not enrolled in the computer-assisted intervention ranged from a low score of 620, which equates to a *needs improvement,* to a 760, which equates to *excellent* (LDOE, 2015). The majority of the scores fell between a 652 to a 682 for both groups. This put the majority scoring *needs improvement* (600-667) or *fair* (668-699).

The distribution of the data is shown in Table 3 and the mean and standard deviation for the Algebra EOC score are given in Table 4.

Table 3

Composition of Algebra by EOC Scores

Score	No Intervention	Intervention	Total
620-651	8	4	12
652-682	27	25	52
683-713	5	17	22
714-744	8	4	12
745-775	2	0	2

Table 4

Descriptive Statistics for Algebra EOC Scores

Group	*N*	*M*	*SD*
Computer-assisted intervention	50	680.08	22.26
Non computer-assisted intervention	50	678.64	32.11

Results for Geometry EOC Score

Data Screening

For the ANOVA to be credible, several assumptions must be met. First, the independent variable must be categorical and the dependent variable interval. Since the dependent variable was the Geometry EOC score and it was an interval level variable, the datasets met the first criteria for an ANOVA. Next, there are to be no extreme outliers in the dataset. The criterion of no extreme outliers was tested by completing the screening of the datasets. Data screening was conducted on the dependent variable Geometry EOC score for data inconsistencies, extreme outliers, and normality. There were no missing values in the files provided, as only students who had a score on the EOC test were sent by the content teacher. Each ID had a corresponding score when the files were examined as a secondary check. To test for extreme outliers, a boxplot was created using the Geometry EOC test score data for both categories of the computer-assisted intervention variable. No extreme outliers were identified (see Figure 1).

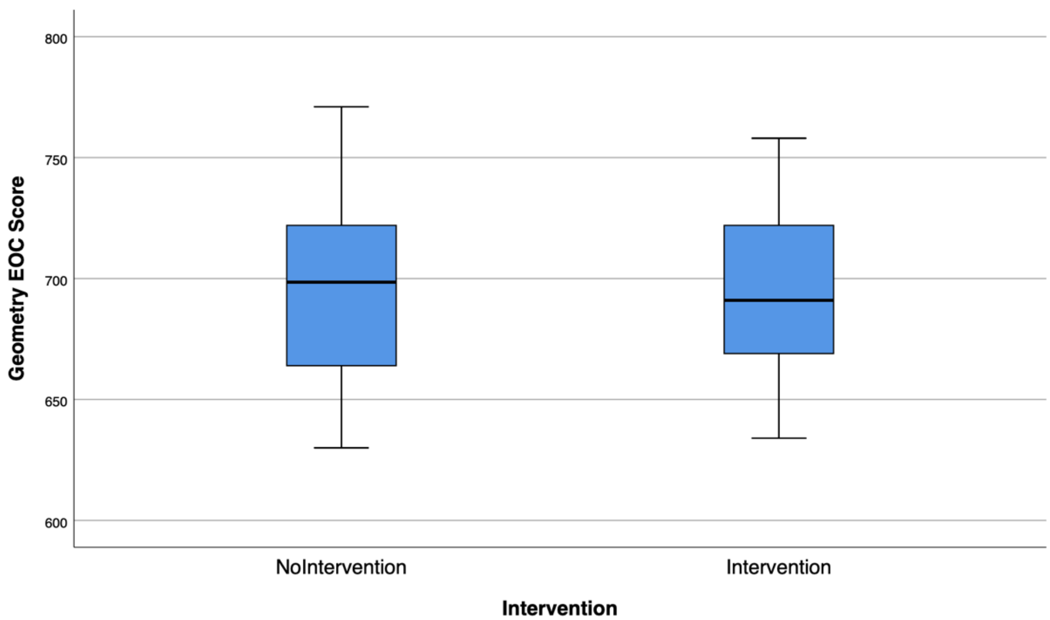

Figure 1. Boxplot of geometry EOC scores.

Assumption Testing

After the data screening was successfully conducted, the next assumption that was evaluated was the assumption of normal distribution (Warner, 2013). To determine if the assumption of normality could be met, a Shapiro-Wilk test was used on the Geometry EOC test scores since the groups had 50 data values (Gall et al., 2007). No violations were found for the dependent variable using the Shapiro-Wilk test. Next, the homogeneity of variances assumption was tested using Levene's test and no violation was found.

Null Hypothesis One

The first null hypothesis states, "There is no significant difference between the Geometry EOC test scores of students who are enrolled in a computer-assisted math intervention program and students who are not enrolled in a computer-assisted math intervention program." An ANOVA was conducted to analyze the difference in means between the nonintervention group (*M* = 695.52, *SD* = 34.42) and the intervention group (*M* = 692.66, *SD* = 34.25).

The ANOVA was not significant, $F(1,98) = 0.173$, $p = 0.678$, partial $\eta^2 = 0.002$. The results indicated there was no significant difference in the mean EOC test scores of the computer-assisted intervention group and the non-computer-assisted intervention group. The first null hypothesis was accepted.

Results for Algebra EOC Score

Data Screening

For the ANOVA to be credible, several assumptions must be met. First, the independent variable must be categorical and the dependent variable interval. Since the dependent variable was the Algebra EOC score and it was an interval level variable, the datasets met the first criteria for an ANOVA. Next, there were to be no extreme outliers in the dataset. The criterion of no extreme outliers was tested by completing the screening of the datasets. Data screening was conducted on the dependent variable Algebra EOC score for data inconsistencies, extreme outliers and normality. There were no missing values in the files provided, as only students who had a score on the EOC test were sent by the content teacher. Each ID had a corresponding score when the files were examined as a secondary check. To test for extreme outliers, a boxplot was created using Algebra EOC test score data for both categories of the computer-assisted intervention variable. No extreme outliers were identified (see Figure 2).

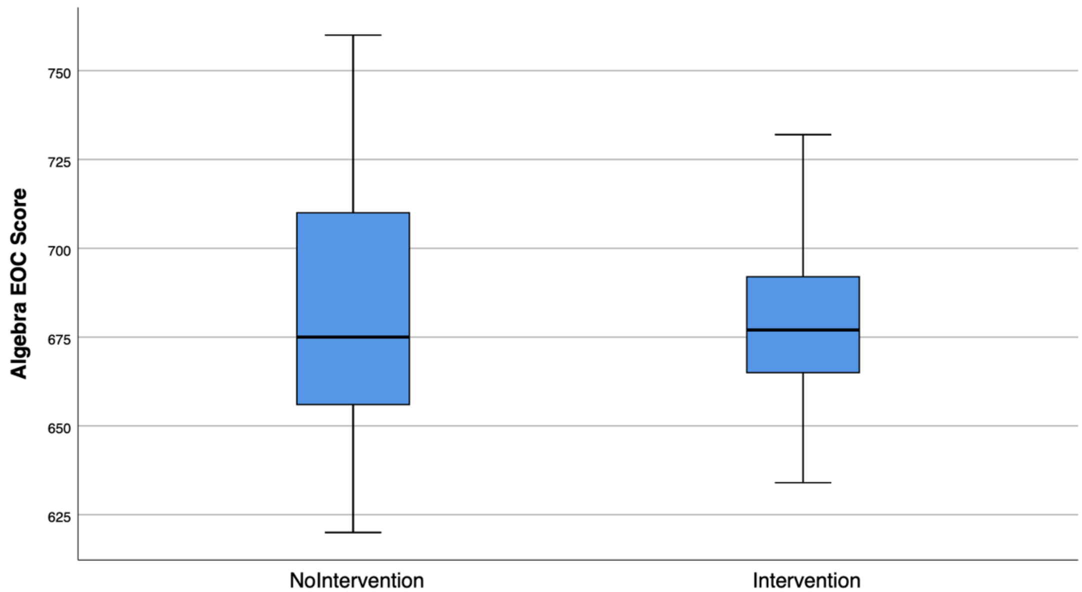

Figure 2. Boxplot of algebra EOC scores.

Assumption Testing

After the data passed screening, the next assumption that was evaluated was the assumption of normal distribution (Warner, 2013). To determine if the assumption of normality could be met, a Shapiro-Wilk test was used on the Algebra EOC test scores since the groups had 50 data values (Gall et al., 2007). No violations were found for the dependent variable using the Shapiro-Wilk test. The assumption of homogeneity of variances was tested using Levene's test and violation was found (see Table 5). The assumption of homogeneity of variances was not met for the variable Algebra EOC test. However, because ANOVA is considered robust to violations of the assumption of equality of variances, the researcher determined to proceed with the analysis (Gall et al., 2007).

Table 5.

Levene Test for Equality of Variances

Algebra EOC Score	Levene Statistic	df1	df2	Sig.
Based on mean	4.93	1	98	.03
Based on median	4.77	1	98	.03
Based on median with adjusted *df*	4.77	1	98	.03
Based on trimmed mean	4.90	1	98	.03

Null Hypothesis Two

The second null hypothesis states, "There is no significant difference between the Algebra I EOC test scores of students enrolled in a computer-assisted math intervention program and students not enrolled in a computer-assisted math intervention program." An ANOVA was conducted to analyze the difference in means between the non-computer-assisted intervention group (M = 678.08, SD = 21.11) and the computer-assisted intervention group (M = 680.08, SD = 22.26).

The ANOVA was not significant, $F(1,98) = 0.068$, $p = 0.795$, partial $\eta^2 = 0.001$. The results indicate that there was no significant difference in the mean EOC test scores of the non-computer-assisted intervention group and the computer-assisted intervention group. The second null hypothesis was accepted.

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter discusses the results of the analysis, as well as conclusions based on the analysis performed. Limitations of the study are examined and recommendations for further research are made.

Discussion

Archived data was utilized from a southern state virtual school for Algebra I and Geometry EOC test for the years 2015-2016 or 2016-2017. The data was separated into two groups within each subject area, one that participated in the computer-assisted math intervention and one that did not. To make the groups more homogenous, only students with a C or below were included in the group of students who did not use the computer-assisted math intervention. Of those not enrolled in a computer-assisted program, only those with a C or lower were considered in this study. This is due to the trigger for an invitation to the computer-assisted math intervention was a C grade at any point in the first nine weeks of the course. All students in Algebra I or Geometry were able to request to be added to the intervention, however, only students with a C or below were actively recruited. In a recruitment effort, once the C grade triggered the process, their math teacher reached out to the family encouraging them to enroll in the computer-assisted math intervention. In addition, after the teacher reached out to the families the teacher for the computer-assisted math intervention also reached out to the family to encourage them to consider joining the computer-assisted math intervention. Parents and families could then attend an information session on the program so that they were familiar with the expectations, and then could make an informed decision on enrollment. This targeted process resulted in a treatment group that had a lower average than the control group for the study. To keep the groups similar for comparison, only students with a C or below were included in the control group of students who did not take the intervention class. This brought the averages closer and controlled for outside influences such as a stronger foundation in the math courses prior to those in the study.

The raw data had 72 Geometry students enrolled in intervention and 82 students not enrolled in intervention who met the grade criteria. For Algebra I, the raw data had 68 Algebra I students enrolled in computer-assisted intervention and 74 students not enrolled in computer-assisted intervention. In order to maintain a medium effect size and a statistical power of 0.7, a group of $n = 100$ is the minimum sample size (Gall et al., 2007). With the raw data sets themselves varying from 68 participants to 82, choosing 50 from each group allowed for random selection, which increased the rigor of the analysis. Therefore, from the file, 50 participants for each group were selected randomly using SPSS to be a part of the analysis for this study.

In the computer-assisted math intervention program, the design of the program included six daily problems for students to complete in Math XL. The problems were based on the objectives covered in the daily lesson in the math course, as well as the assessment questions within the course for that unit. The students enrolled in the computer-assisted math intervention interacted with the Math XL program and utilized tools, including *Show Me an Example* and *Help Me Solve This,* to gain an understanding of the problems. Students were allowed unlimited attempts to get the problems right and could contact the interventionist for help, if necessary. This computer-assisted math intervention program was implemented for students in the 2015-2016 and 2016-2017 academic years enrolled in Algebra I or Geometry. In May of each year, the students took the EOC exam to test their mathematics achievement and proficiency in the content. The scores were used in this study according to the guidelines for each group: intervention and nonintervention.

Findings for Research Question One

Research question one examined whether there was a significant difference in the mean of the Algebra I EOC scores between students who received computer-assisted math intervention and those who did not receive computer-assisted math intervention. When comparing the means, no significant differences were found between the two groups of students. Therefore, the null hypothesis failed to be rejected. The result suggests that receiving computer-assisted math intervention did not increase mathematics achievement as measured by the Algebra I EOC test.

Findings for Research Question Two

Research question two examined whether there was a significant difference in the mean of the Geometry I EOC scores between students who received computer-assisted math intervention and those who did not receive computer-assisted math intervention. When comparing the means, no significant differences were found between the two groups of students. Therefore, the null hypothesis failed to be rejected. The result suggests that receiving computer-assisted math intervention did not increase mathematics achievement as measured by the Geometry EOC test.

Discussion Based on Theory

The purpose of this study was to determine if computer-assisted intervention had an effect on mathematic achievement, measured by the performance on the EOC test for Algebra I and Geometry. A causal-comparative design was used to complete the study.

Math achievement is a very controversial topic in the current state of domestic and international education, and reports point to deficits in mathematics abilities (Lee, 2012; NCES, 2013; NCES, 2015a; OECD, 2013). These deficiencies can potentially lead to a shortage of students prepared for higher education academia or for careers in STEM fields, which will, in turn, lead to fewer workers specializing in those fields. In addition to this concern, online schools have continued to see an increase in enrollments as parents seek better options for their child's education, greater flexibility in course offerings, or adequate accommodations for medical conditions. This is one reason that online schools have a larger population of students with exceptionalities that require special education services (Carpenter et al., 2015). However, understanding of nonspecial education students is limited, due to little research on nonspecial education students enrolled in online schools. While there is little data for nonspecial education students, it is true that online schools have proven to have a role in increasing the academic growth of special education students (CREDO, 2015). Since online schools serve a large proportion of students with health, academic, or emotional challenges, the school must examine a wide variety of potential RTI programs with realizable gains that can impact academic achievement for a population with variable needs.

Active learning theory contributes to understanding the outcomes of this study. Peirce (1985), as an advocate of active learning theory, challenged all aspects of the learning process. Furthermore, he challenged the idea that active learning is only done with hands on activities. Peirce (1985) believed that teachers should not give direct instruction to students but should guide students with thought-provoking prompts that allow the students to make conclusions of their own (Liszka, 2013). In active learning theory the process of going through a guided inquiry-based lesson engages the student in the content and leads to mastery of the concept beyond simple knowledge. The active learning theory further suggests that this process allows students to apply the knowledge they learn through the guided inquiry process to other applications of the concept and problems set in the real world (Buchler, 2016).

The concept of computer-assisted math intervention was used to test this theory in the study. The computer software prompted students through problems using features like "Help Me Solve This" and "View an Example" within the software. These processes were step by step guided inquiries where students are asked to complete the calculation for each step with prompts provided by the software. The teacher guided students by choosing problems that were related and that allowed students to identify patterns in the problem-solving process. The software then created a study plan for students to use as a self-guided review on deficit areas found through analyzing the data from the assignments. Through this process, the computer software engaged students in active learning while students worked to master math concepts and then apply the concepts to new problems. This was accomplished by presenting slight variations of problems in the study plan that allowed students to learn by actively solving problems and then applying patterns realized to new slightly different variations. Students have ownership of the study plan and therefore actively chose what to work on as well as engaged in learning the concepts actively through the *Help Me Solve This* tutorials and *Show Me An Example* tutorials. This process guided students to identify patterns and develop a stronger understanding of math content in hopes of increasing mathematic achievement. In this study, end of course exams for Algebra I and Geometry were utilized to measure level of math understanding for students utilizing computer-assisted instruction and those not using computer-assisted instruction.

Discussion Based on Previous Research

In this study, the application of active learning theory was tested in an online secondary school setting. Waters, Barbour, and Menchaca (2014) estimate that in 2016 there were roughly

4.8 million virtual and cyber online students in K-12 education in the United States . Online schools continue to grow in popularity, yet there are questions about the academic achievement for students in these environments (CREDO, 2015; Glass & Welner, 2011; Hubbard & Mitchell, 2011). Online schools are an attractive option for families with exceptional students as there are more hands-on opportunities for families to be involved directly in the education of an exceptional child. Families have the ability to see exactly what is being learned from viewing their lessons and get real time grades. This level of involvement is very attractive for parents of special education students (Coy & Hirschmann, 2014). In addition, CREDO (2015) found that online schools reduce the impact of achievement on special education students. Students in special education face unique practical challenges in the classroom and accessing the general curriculum can be difficult (Kuo, 2014). Furthermore, instructional time is often reduced due to various therapies or appointments these students must attend in addition to schooling. Thus, there has been speculation that academic achievement may be lower in an online setting (CREDO, 2015), however, this results from a larger population of special education students and subsequent lower achievement scores from students with more profound exceptionalities that attend online school. Specifically, the study found that math academic achievement in online charter schools was significantly improved for special education students when studied apart from nonspecial education students. While there is a body of literature on special education students and their achievement in online settings, there is a lack of understanding or data on the population of an online school as a whole (Coy & Hirschmann, 2014). In this study RTI was examined to determine if there was an overall increase in mathematics achievement for both special and nonspecial education students. To do this the effect of computer-assisted mathematics intervention was examined as it related to increased instructional time, individualized learning and applying active learning theory.

This study also contributed to understanding of Response to Intervention as a program practice. RTI is a common framework for intervention to be used with struggling populations of students and is particularly used with exceptional students or lower achieving students. RTI was added to IDEA in 2004 as a different evaluation process for schools, with the goal of identifying students with learning differences and providing appropriate interventions (Turse & Albrecht, 2015). Computer-assisted math intervention meets the criteria for a RTI process and is aimed at increasing mathematic achievement (De Witte, Haelermans, & Rogge, 2014; Wilder & Berry, 2016; Ye & Herron, 2012).This study sought to examine the impact of self-guided inquiry as a RTI process in mathematics. This study showed that in the context of the findings, using computer-assisted math intervention as an RTI was not successful. There was not a statistically significant difference in the mean values for those in the RTI program which indicates that the computer-assisted intervention did not serve as a successful RTI implementation.

This study sought to examine the impact of a computer-assisted math intervention program as an RTI on mathematic achievement using the end of course test score as a measurement. The computer-assisted instruction under examination was Pearson's Math XL, yet with a lack of data on Pearson's MathXL at the secondary education level, the study extended the knowledge on its use by obtaining data concerning its impact on students taking the Louisiana EOC test for Algebra I and Geometry. While there are some studies about using MyMathLab (the higher education version of Math XL) or a similar program, these are geared toward higher education and not secondary school settings. The findings in higher education are mixed on computer-assisted intervention. There are some studies that have found positive results in the higher education setting with using a computer-assisted math intervention (Hu et al., 2012; Wilder & Berry, 2016; Ye & Herron, 2012). However, some studies have found that a computer-assisted math intervention did not impact mathematic achievement for a college algebra course (Kodippili and Senaratne, 2008; Vilardi & Rice, 2014).

Analysis of the Research Question Findings

Both null hypotheses failed to be rejected, meaning that there truly was no significant difference in mathematic achievement for students taking the Geometry or Algebra I EOC test, whether they were only enrolled in the math course or the computer-assisted math intervention. These results show that when active learning theory is applied through a computer-assisted math intervention, in this sample, it was not effective in increasing mathematic achievement, by a statistically significant amount, at least for students in an online school. This contradicts research on self-guided inquiry as an instructional practice (Peirce, 1985; Liszka, 2013). It was expected that students in the computer-assisted intervention should have experienced a mastery of mathematic concepts through the guided inquiry of the computer program that would allow them to apply the same process to different problem sets that are asked in various manners. This would actively engage the learner in the content and in the process of finding a solution. In active learning theory this would result in increased retention and allow for scaffolding into various representations of the concepts in different problem representations. Furthermore, previous research into active learning theory, with regard to the use of computer-assisted math intervention, showed gains in understanding of concepts that would lead to mastery of content and an increase in academic achievement (Gulwani, 2014; Lerman, 2012).

Active learning theory drove this study, as the use of a computer-assisted learning program allowed the students to interact, through self-guided inquiry, with the software to learn the material as they worked through assignments (Gulwani, 2014). Research conducted to prepare for this study, showed guided inquiry using computer-assisted math intervention reduced the deficit in mathematics skills for students (Demir & Basol, 2014; Wilder & Berry, 2016; Ye & Herron, 2012). However, the findings of this study show that in this context, the computer-assisted math intervention, implemented in an online school setting, failed to increase mathematic achievement through active learning.

Implications

Studies have clearly demonstrated a widening gap with mathematic achievement within the United States and internationally (Lee, 2012; NCES, 2013; NCES, 2015a; OECD, 2013). Most recently, the National Center for Education Statistics released the 2019 results for *The Nations Report Card*, showing a continued decline for 8th-grade math students. In addition, lower-performing students in the 10th and 25th percentiles saw a decline in performance on mathematics achievement tests from just two years prior in 2017. This continues to show the need for effective teaching and learning strategies in secondary classrooms. While active learning theory has been shown as an effective instructional strategy to help students generalize knowledge from one context to the next (Buchler, 2016), in the context of this study, it did not aide students in generalizing knowledge in mathematics to achieve a higher score on the Algebra I or Geometry EOC test. The implication of this finding is that computer-assisted math intervention as an active learning instructional strategy may not necessarily be effective at closing the gap in mathematic achievement, in an online format, domestically or internationally. This shows that other instructional strategies should be researched along with other RTI options to close the achievement gap to keep Americans competitive in the international job market and to ensure secondary students are prepared for higher education.

Publishers are continuing to build computer-assisted math intervention programs into their curriculum and selling them to customers. Cengage now has a package with an online computer-assisted program for secondary customers (Lazers, R. personal communication, December 10, 2019). Pearson also has its MathXL platform as a strong intervention program for secondary education (Wilson, L. personal communication December 7, 2019). This push toward computer-assisted math intervention from secondary education publishers creates an urgency for research regarding whether programs can increase mathematic achievement. While some studies have shown an increase in mathematics achievement using computer-assisted math intervention (Demir & Basol, 2014; Ye & Herron, 2012), the results of this study contradict this. However, the findings of this study do contribute to understanding the outcomes for computer-assisted math intervention in online settings. The implementation of using a teacher guided problem set with no grading may not necessarily create the desired outcome for students. These desired outcomes include increased confidence and attitude toward mathematics, increase in ability to self-direct learning and the ability to navigate technology. We know that attitudes toward mathematics do affect achievement (Arslan, 2012). This is one facet of the study that was not explored but should be examined in future studies. While, the results of this study eliminate one implementation strategy for computer-assisted math intervention, there are other facets to these programs that can be explored. Some implementation strategies could be graded use of the program as well as other self-guided features that allow students to self-select problem sets (Hu et al., 2012; Wilder & Berry, 2016; Ye & Herron, 2012). This study opens doors for further examination into outcomes from different implementations of computer-assisted math interventions to improve student outcomes in mathematic achievement. This outcome gives schools information to make curriculum decisions as publishers continue to create and sell computer-assisted math intervention programs.

This study was conducted with a population of online students from the state of Louisiana. The population of online schools continues to include large numbers of students with learning challenges, as they do not fit in a traditional classroom. This study did not control or measure data on the potential learning challenges within the sample used. Several studies demonstrated that online schools do not perform on the level of their counterparts; however, when there is no control for the social, emotional, or health issues of students, the online schools perform admirably compared to the traditional learning environment (CREDO, 2015; Glass & Welner, 2011; Hubbard & Mitchell, 2011). This study contributed to the body of knowledge on the performance of online students, as the average scores were passing EOC test scores. This adds to the body of knowledge that online schools can have positive outcomes for students based on the outcomes of the EOC test scores. According to the LDOE (2019a), the percentage of *needs improvement* statewide was 17% for both Algebra I and Geometry in 2016. The percentage in 2017 was 15% for Algebra and 19% for Geometry (LDOE, 2019b). This study found that, for the sample overall, the percentage of *needs improvement* was 27% for Algebra I and 24% for Geometry. This contributes to the knowledge of online schools and student mathematic achievement. Although the study did not find a significant difference in the means of the two groups, the mean score is not far off from the population of the state of Louisiana which is largely from brick and mortar schools. This further implies that computer-assisted math intervention as an RTI in this setting and context is not effective for students needing additional support to access the mathematics curriculum. However, the comparison of scores lends some credibility to the online school movement and warrants further research into mathematic achievement of students online as compared to their counterparts that attend school at a brick and mortar institution.

Limitations

A few threats to the validity of this study should be addressed. First, since the study consisted of archival data, it was not possible to randomly assign participants to the treatment groups. This required that the study be conducted as causal-comparative and left it possible for differences in the characteristics of the participants to affect the outcome, in this case, the EOC test score (Creswell, 2009). It was not fully possible to explain differences in the mean between the two groups using only the treatment of computer-assisted math intervention.

In addition, the groups formed through random selection of the matched groups may not have been fully representative of the population since non-random sampling was used (Gall et al., 2007). This was controlled by matching the samples to keep the homogeneity of the participants in each group. The matching factor was the grade of a C or below in the course to allow for the nonintervention group to match the intervention group. Further complicating the analysis, the limited sample size and highly specific population should also be considered. The number of students sampled was a small group despite having the appropriate statistical power of 0.7. In relation to the population of the school, this was a small portion of the total enrollment in the Algebra and Geometry courses and could influence the results (Gall et al., 2007). In addition to the small sample size, the intervention was not graded or conducted under the supervision of a teacher. Students did not receive a grade for completing the intervention work, so there was not firm accountability or extrinsic motivation.

Another threat to internal validity occurred due to the dissimilar sizes of the groups before the random selection occurred. A larger population of students had a C or below but did not participate in the computer-assisted intervention. While an effort was made to equalize this through random selection of participants from each group (*N* = 50), this still poses a threat to internal validity (Creswell, 2009).

Furthermore, the results and findings of this study are limited in the ability to generalize to the larger population of secondary math students or even online secondary math students. This is because only one school participated in the study, and it is in the state of Louisiana. Therefore, this would make it inaccurate to generalize to schools outside of the state since curricula vary as well as testing practices. In addition, during the years of the data gathered, there was only one other online school in the state and this could not be generalized to them, as they did not have a math intervention program and did not utilize the same software or curriculum. In addition, the demographics of online schools also tend to have larger populations of students with learning challenges. This also makes it difficult to generalize to the general population, as online schools have a higher proportion of students with 504s or individual education plans (Carpenter, Kafer, Reeser, & Shafer, 2015).

Last, the instrument itself also posed some threat to the validity of student as the test format should be considered. The items for the EOC test were not formatted using the same wording as those in the software using MathXL. This could affect students, as they did not receive additional support with constructed response questions or multi-step questions, as presented in the EOC test (LDOE, 2015). Last, there are nine different versions of the Algebra I EOC test and seven different forms of the Geometry EOC test (D. Hopkins, personal communication, March 3, 2016). Information was not provided for which version each student took, so it is likely the instrument varied within the sample as students take the test online, so the site does not use only one form of the test.

Recommendations for Future Research

A few areas related to this study warrant additional research. First, there should be an experimental study where students are randomly assigned a treatment of computer-assisted math intervention. In most of the studies in higher education, as well as this study, random assignment was not used to create a control group and a treatment group (Demir & Basol, 2014; Vilardi & Rice, 2014; Ye & Herron, 2012). A future study with random assignment and identical curriculum would build upon the research conducted here with a better sample of students who are representative of a population. In addition to randomly assigning students, using several online schools for the groups would give a better picture. There are several national networks of online schools with which this would be possible. Since there are standardized curricula within the math courses, it would be ideal to sample a variety of students across the United States to be able to obtain a true picture of the population with a study that can be generalized to the general online secondary math student population. In addition to the variety and random assignment, a larger sample should be taken for all groups to give a higher statistical power (Gall et al., 2007). A sample group of 50 students is too small to generalize to the U.S. education system, even limiting it to online education.

Next, the different uses of MathXL should be examined, such as the mastery-based option or a fully self-directed option where students navigate by objective. The study plan adapts to students' progress through all objectives for the chapter. This approach differs from the six selected daily questions used in this study. The study plan is more comprehensive and identifies deficits and allows students to spend time on objectives they struggle with while moving them quicker through ones they understand. Students can also practice until they feel comfortable with concepts as the program can present countless variations of a problem for most concepts. Completing a study from this perspective would examine the adaptive side of the software and could be compared to the non-adaptive teacher-guided method.

A study that uses a posttest design aligned to curriculum standards would build upon this research. The EOC test is a valid and reliable instrument, but many versions of the EOC test are used. Schools choose different curricula that may not directly align with all the material on the test. For this reason, a posttest designed using the mathematics curriculum would be a stronger indicator of gains made using computer-assisted math interventions since the software aligns with textbook and course objectives, not standardized testing objectives. Additionally, the EOC test has a heavily weighted constructed response section. The MathXL software does not allow for practice with this type of assessment question, so it warrants further study with a posttest that can match the question style and sequencing of the material in the math lab.

Last, as the software works under the theory of active learning theory more work should be done looking at how students are engaging in the software. This could be accomplished by a survey at the end of a nine weeks or semester in which students are asked how often they accessed the tools *Help Me Solve This* or how they utilized the study plan. This would provide more insight into how students are interacting with the software and if active learning theory is being employed by the student.

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APPENDIX A: Principle Consent

University View Academy

April 15, 2019
Brandi Robinson
Doctoral Candidate
Liberty University
91 Holly Dr.
Laplace, LA 70068

Dear Brandi Robinson

After careful review of your research proposal, "The effect of computer-assisted intervention programs on the achievement of high school mathematics students on a state assessment while attending a virtual school.," I have decided to grant you permission to receive and utilize the End of Course Testing Records for Algebra I and Geometry for the years 2015-2016 and 2016-2017 for your research study.

Check the following boxes, as applicable:

☑ The requested data WILL BE STRIPPED of all identifying information before it is provided to the researcher.

☐ The requested data WILL NOT BE STRIPPED of identifying information before it is provided to the researcher.

Sincerely,

[redacted]

High School Assistant Principal
University View Academy

4664 Jamestown Avenue Suite 100, Baton Rouge, Louisiana 70808
www.universityview.academy 225.421.2900

APPENDIX B: IRB Approval

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

April 29, 2019

Brandi Robinson
IRB Application 3808: The Effect of Computer-Assisted Intervention Programs on the Achievement of High School Mathematics Students on a State Assessment While Attending a Virtual School

Dear Brandi Robinson,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your research with the data safeguarding methods mentioned in your IRB application.

Your study does not classify as human subjects research because it will not involve the collection of identifiable, private information.

Please note that this decision only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued non-human subjects research status. You may report these changes by submitting a new application to the IRB and referencing the above IRB Application number.

If you have any questions about this determination or need assistance in identifying whether possible changes to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

[redacted]

Administrative Chair of Institutional Research
Research Ethics Office

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