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St Math Intervention Participation by Gender on Motivation and Engagement for Elementary Students in Arkansas

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ST MATH INTERVENTION PARTICIPATION BY GENDER ON MOTIVATION AND ENGAGEMENT FOR ELEMENTARY STUDENTS IN ARKANSAS

by

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ABSTRACT

by
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Title: St Math Intervention Participation by Gender on Motivation and Engagement for Elementary Students in Arkansas (Under the direction of Dr. Kimberly Flowers)

The purpose of this study was to determine if participation in the Spatial-Temporal (ST) Math program as an intervention increased students' positive motivation and engagement in two Northwest Arkansas schools as measured by the Motivation Engagement Scale (MES), a self-reported survey. School A participated in ST Math, and School B did not participate in ST Math. Students from all tier levels of instruction composed the sample of 160 fourth-grade students (80 participating and 80 not participating) and 160 fifth-grade students (80 participating and 80 not participating). The gender was equally distributed (40 males and 40 females from each sample group). Both schools had similar demographics including race and socioeconomic status. A 2 x 2 factorial ANOVA was used to determine if a statistical difference existed. The results indicated there was no significant interaction between ST Math participation status and gender on positive student motivation and positive student engagement. No significance existed for Participation Status; however, the fourth-grade females indicated a statistical significance when analyzed separately.

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CHAPTER I

INTRODUCTION

Educators usually follow a basic process in teaching and training young people to be active and contributing members of society. Teachers start with a set of standards created by the state. These standards provide a guide to the content which is taught at a specific grade level (Arkansas Department of Education, 2014). From the standards, lessons are developed to deliver information to the students. These lessons serve to engage students in learning the required standards through the regular education classroom or core instruction, also referred to as Tier 1 instruction. Then, students are assessed for mastery skills based on the standards. However, because not all students learn in the same way and at the same rate, results often indicate achievement discrepancies due to the lack of background information, student motivation, or engagement in the instruction.

Students of both genders may struggle to achieve due to different learning experiences and background knowledge. When students are not making progress or they fall behind in their learning, an intervention is initiated to support closing the students' learning gap (Hoover, Baca, Wexler-Love, & Saenz, 2008). Intervention can also be used as enrichment to challenge or expand students' skills to higher levels. Therefore, an intervention continuum ranges from promoting support for learning deficits to providing support for advanced tasks. The learners' behaviors are classified into two categories:

skill and will (Metallidou & Vlachou, 2007). *Skill* is based on whether students can complete the task, and *will* involves the students' motivation and engagement in the learning experiences. Students' learning experience impacts their academic growth.

Technology has become a popular tool for interventions because these are tailored to students' needs, the ease of data collection, and student engagement. Mathematics instruction and intervention has changed with the advances in technology and the development of software that makes learning interactive, challenging, and fun. The technology used in mathematics interventions is engaging with game-like formats that are customized to individual students' needs. Technology-based mathematics programs such as DreamBox Learning Math, Learning.com; Aha!Math, IXL Math, Wowzers Math, ilearn Math, Carnegie Learning, TI MathForward, Shmoop Learning Guides, Maple 16, and Spatial-Temporal (ST) Math (Williams, 2013) are currently used around the country to support mathematics instruction. Technology can also be more structured to meet the individual student's needs, as well as a reliable tool for teachers for data analysis.

ST Math is one form of technology used for mathematics instruction and interventions. The key concept behind ST Math is that the program removes language barriers that could inhibit achievement, according to Wendt, Rice, and Nakamota (2014). The program is designed using a game format with a trial and error approach to solving mathematics problems and structured to each student's current level of learning with set learning progressions (Peterson, 2012; Wendt et al., 2014). Due to the program's design, ST Math is often used for an intervention to close learning gaps and help students master concepts related to grade-level standards.

Statement of the Problem

The purposes of this study were four-fold. First, the purpose of this study was to determine the difference by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the Motivation Engagement Scale (MES) for fourth-grade students in Northwest Arkansas elementary schools. Second, the purpose of this study was to determine the difference by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools. Third, the purpose of this study was to determine the difference by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools. Fourth, the purpose of this study was to determine the difference by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools.

Background

Many schools use the Response to Intervention (RTI) model for providing interventions because students do not achieve at the same rate, nor do they all begin with the same levels of background knowledge. When students fall behind in meeting the standards for a grade level, teachers are required to provide interventions according to No

Child Left Behind (2002). Interventions are also used for enrichment purposes to challenge students beyond grade-level expectations. Many types of interventions are related to behavior and academics. The definition of an instructional intervention is a specific program or set of steps implemented for the student in a specific area of need (Lee, n.d.). The RTI model encompasses three tiers (Tiers 1, 2, and 3), is very structured, and has specific progress monitoring at each of the different tiers.

Technology helps students connect and learn beyond the walls of the classroom. Teachers embrace the use of technology in classrooms to instruct students and keep them motivated and engaged (O'Rourke, Main, & Ellis, 2013). Internet accessibility has become an essential tool for gaining information, communication, and learning in schools. The innovation in technology has even made access possible for virtual schools and online courses to supplement educational experiences. The purpose of technology integration is not to replace pencil-and-paper tasks but to extend learning capabilities and opportunities that are available (Carr, 2012). Technology helps teachers differentiate instruction to meet the needs of individual students. By using technology in classrooms, real-world connections are formed, therefore engaging students in their learning experiences and applying the learning outside of the classroom.

When teachers develop lessons to promote active student engagement, motivation increases in classrooms. Students cannot learn if they are not engaged in the learning process, and this learning begins with building student relationships. Students tend to be more motivated to participate in class if they feel that the teacher cares for them and encourages their effort (Stephens, 2015). Motivation and engagement, though, are different yet work together.

Instructional Intervention

Instructional interventions are systematic supports that provide students remediation to close academic deficits or to enrich and encourage academic growth. Interventions are implemented to assist students who fall behind in skills or subjects. Enrichment interventions are used to expand skills. The purpose of the intervention is to help struggling students gain the needed skills or keep students challenged for successful academic or behavioral achievement through small group instruction (Fuchs & Fuchs, 2009; Lee, n.d.). Instructional interventions involve progress monitoring of students to ensure that interventions are effective in the targeted skill. Many schools use a multi-tiered intervention system where the intensity of instruction increases at the different level of tiers (Kupzyk, Daly, Ihlo, & Young, 2012). Instructional interventions have specific steps to follow for intervention or enrichment.

The George W. Bush administration supported RTI in the early 2000s as a more valid way to identify disabilities and as a promising way to reform general education. This intervention type became a part of the amendments to the Individuals with Disabilities Education Act (Fuchs & Fuchs, 2017). The number and types of interventions through technology use have increased with advances in digital formats. According to Edyburn (2018), three common forms of technology that are used in interventions are universal design for learning, instructional technology, and assistive technology. Universal screenings of all students help instructional designers build supports and scaffolds into the instructional environment, which helps prevent failures.

Well-designed instructional technology tools help provide supports and engagement for struggling learners. Assistive technology supports students through mobility, communication, or motor and sensory tools. Text-to-speech is an example of assistive technology that can assist a struggling learner. The purpose of RTI is to provide a systematic approach for screening, intervening, and monitoring students' academic growth.

Role of Technology for Mathematics Intervention

Technology has evolved and is an integral part of classroom instruction. Technology has an impact on students' learning by providing more engagement through hands-on learning experiences (Costley, 2014). Teachers use technology to provide instruction and intervention, track data, monitor progress, and provide learning opportunities that differentiate lessons based on a student's individual needs. Technology use in the classroom also supports skills to prepare students for life beyond school.

Many types of programs have been developed to engage students in learning through a game-like format, which grabs their attention and keeps them involved in the learning. When students are engaged in these game-like activities, they are learning and improving academically (Mendez & del Moral, 2015). The teacher's role has changed from the disseminator of information to the facilitator of students' learning with the use of digital learning tools (O'Rourke et al., 2013). When students have choices, they are more motivated to complete their work. Educators must be selective about the different educational programs to ensure that motivation, engagement, and learning of desired concepts are achieved.

ST Math

ST Math involves visual representation, symbolic representations, and techniques for problem-solving in mathematics. ST stands for *spatial-temporal*, and during the development of ST Math, researchers discovered that the human brain tends to hold visual representation in short-term memory while thinking several steps ahead (ST Math, 2016). The ST Math program provides an "effective blended learning math solution for K-12 education" (ST Math, 2016). The coursework, or lesson, involves proficiency through visual learning and is in a game-like format with a mascot, JiJi, who guides the learning progression. The visual aspect of the ST Math program demonstrates problem-solving skills, reducing any language-barrier issues that affect the learning progression.

The ST Math program was initially tested in California. Wendt, Rice, and Nakamoto (2014) reported on the evaluation of the ST Math program for 209 schools in California that had fully implemented the program to measure increased achievement for the state assessment. The ST Math program was designed to progress with the students as they acquired concepts. This strategy was based on trial and error for solving the problems in the games (Vander Ark, 2012). The ST Math program has no words; therefore, language barriers are removed. Vander Ark (2012) also noted that California had a high population of English Language Learners in schools. These English Language Learners became a target group to test ST Math because the terminology used in mathematics had created language barriers for students and hindered the accurate measurement of the students' mastery of content.

Gender

Some believe males achieve at higher levels in mathematics than females and even further state that the differences are attributed to biological or hormonal differences that are encoded on the Y chromosome (Wade, 2010). Wade (2010) reported that males tend to score better on standardized mathematics assessments; however, females frequently outperform males in class assignments. Ganley and Lubienski (2016) noted that gender differences in mathematics achievement are relatively small, which are usually measured with a small effect size (Cohen's *d*) of .1 to .3. Research indicated that males and females approach problem-solving strategies differently (Ganley & Lubienski, 2016). Societal views about mathematics achievement appear mixed in claims that males are better than females in the area of mathematics and careers involving mathematics.

Attitude and self-confidence play a role in mathematics achievement. Azar (2010) noted that males tend to demonstrate more self-confidence than females in solving mathematics problems. Other factors that could relate to the differences in mathematics achievement between males and females are cultural biases, family influences, and the socioeconomic status of parents (Ajai & Imoko, 2015). Males tend to be stronger with abstract spatial thinking skills than females, which relate to the prediction of better mathematics performance in Science, Technology, Engineering, and Mathematics (STEM) career choices (Ganley & Lubienski, 2016). Ganley and Lubienski (2016) reported that teachers' mathematics anxiety or views are often transferred to female students creating in them a sense of uncertainty in their ability. Mathematics achievement occurs with practice and trust in one's ability to solve problems.

Motivation and Engagement

Motivation is the force that drives human behavior or actions. Farley (n.d.) explained that intrinsic and extrinsic are the two main types of motivation. Intrinsic is when a person is internally motivated to complete a task for the sake of completing the task; whereas, extrinsic motivation is when a person is promised something in return for completing the task. Motivation is a three-part model that includes direction, intensity, and persistence (Farley, n.d.). The direction is the goal that an individual sets to work to accomplish. Intensity relates to the amount of effort one puts forth toward achieving the goal. Persistence is the duration that an individual spends putting forth an effort to reach the desired goal. (Farley, n.d.). These three parts comprise what drives student behaviors or actions.

Five components of motivational strategies for student learning were noted in the literature review: self-efficacy, intrinsic value, emotional reaction, cognitive strategies, and self-regulation (Metallidou & Vlachou, 2007). Self-efficacy is a motivational component of how students choose their tasks and the amount of effort they apply to the tasks. The next component is related to personal interest or intrinsic motivation that a person has toward the task. When a task has intrinsic value to the students, they want to perform well on the task. Another component of motivation is the students' emotional reactions to a task. Test anxiety is an example of how an emotional reaction can negatively influence achievement. Cognitive strategies involve the comprehension of the lesson that is taught. Cognitive strategies are defined as students' abilities to learn, often referred to as skills. Metallidou and Vlachou (2007) discussed the impact of the *will* versus *skill* concept and how this impacted student achievement. Self-regulation is key to understanding how students initiate, monitor, and exert control over their learning. These five key components are essential in student motivation and explain how students process information.

Student engagement is interest and enthusiasm through participation. Like motivation, engagement has three key components: behavioral engagement, affective engagement, and cognitive engagement (Olson & Peterson, 2015). Behavioral engagement refers to the students following rules in the classroom or school. Affective engagement involves a student's sense of belonging, interest, and willingness to learn or how a student feels about school. Cognitive engagement is how the student processes information. Students possess varying degrees of engagement. Research indicates that student engagement is necessary for the students to gain knowledge and skills to achieve both academically and in future careers (Olson & Peterson, 2015). Understanding what student engagement is assists schools in improving student participation and achievement.

The learning environment has an impact on a student's motivation and engagement. Galloway (2016) noted that a simple overview of motivation theory is that one's needs drive his/her behavior to reach satisfaction or to avoid dissatisfaction, and motivation is considered the *why* and engagement is the *what*, or in other words, wanting to do something versus having to do something. To be engaged is thought of as an emotional commitment. Motivated people are excited and want to complete the task. Teachers should cultivate a learning environment that provides students with opportunities for active engagement, keeping them involved and motivated to participate.

Hypotheses

1. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools.
2. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus

students not participating on positive student engagement as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools.

3. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools.
4. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools.

Description of Terms

Achievement gap. An achievement gap refers to the difference in academic performance between different groups of students measured by state standards (Ansell, 2011).

Engagement. Stephens (2015) defined engagement as the tendency to be actively, behaviorally, emotionally, and cognitively involved in academic activities.

Enrichment. Enrichment provides students with challenges to acquire an understanding of the curriculum at a deeper level (Gray, n.d.).

Instructional Intervention. An instructional intervention is a specific program or set of steps to assist a student with areas of need (Lee, n.d.).

Motivation and Engagement Scale (MES)—Junior High (JS). Developed by Martin (2015), the MES is a multi-dimensional conceptual framework that represents intellectual and behavioral dimensions applicable to motivation and engagement for ages 9 through 13.

Motivation. Motivation is high-level energy focused on a productive action to complete a task (Galloway, 2016).

Response to Intervention (RTI). RTI is an organized, school-wide approach with increasing levels (Tiers 1, 2, and 3) of concentration, providing instruction to students with diverse educational needs who are not making sufficient progress toward meeting state standards (RTI Action Network, n.d.) and for those who have advanced learning needs requiring more pace, complexity, and depth (National Association for Gifted Children, n.d.).

Spatial-Temporal Math (ST). ST Math is a software program that uses spatial-temporal reasoning capabilities to help students understand and solve multi-step mathematics problems in a game-like format (Williams, 2013).

Universal Design for Learning and Technology. Universal Design for Learning and Technology is a method of instruction that addresses the needs of students by proactively planning for instructional, environmental, and technology supports to allow students to effectively access and engage in instruction (Basham, Israel, Garden, Poth, & Winston, 2010).

Significance

Research Gaps

Students arrive at school with varying abilities and background knowledge. Thus, educators are becoming more aware of the need for closing achievement gaps. Increased state and federal achievement accountability are evident by the Individuals with

Disabilities Act and No Child Left Behind Act (Ansell, 2011). Interventions are developed to assist struggling learners to acquire targeted skills and to challenge advanced learners. With the increases in technology, many educators are using software programs and web-based interventions to close the learning gaps or promote achievement and build up the abilities and background knowledge of all students.

The use of technology is increasing in classroom instruction. According to Smith (2017), districts are implementing digital curriculum for mathematics instruction that provides data that aids in strategic decisions while meeting students' individual needs. The technology that one chooses to use needs to be engaging and age-appropriate for the students (Smith, 2017). Technology integration has been included in the curriculum standards and objectives for different teaching and learning strategies to meet individual student's needs (Ozel, Yetkiner, & Capraro, 2008). Incorporating technology in classrooms supports individual student instruction in classrooms.

Many researchers have recognized a need to evaluate the connection between technology interventions with achievement, but only a few studies have been conducted that focus on motivation and engagement with technology interventions by using specific mathematic technology programs. Bruhn, Vogelgesang, Fernando, and Lugo (2016) conducted a study that focused on students' use of technology as a tool for self-monitoring interventions. The use of technology tracked the data for the individual and provided information needed for implementation. This type of technology use as an intervention is valuable for educators, parents, and students. More research should be conducted to determine how technology interventions influence motivation and engagement.

Possible Implications for Practice

Twenty-first-century children live in a digital world; therefore, the increased use of technology is a needed resource in all classrooms to maintain students' interests. School districts should focus on the following critical questions when evaluating the effectiveness and addressing the intended academic purposes (Klieman, 2004; Ozel et al., 2008): What types of technology should the school use? What are the purposes of each type of technology chosen? Does the type of technology support the differentiation of instruction? The research of this study provided information and data regarding ST Math by determining if this program had a statistically significant effect on student motivation and engagement. Another factor examined was if gender, alone or in combination with ST Math, had an impact on student motivation and engagement. Today's students are accustomed to accessing information at their fingertips; therefore, learning has to include technology to keep them engaged.

This research was significant because it added quantitative data of technology intervention for mathematics relating to student motivation and engagement and provided information to determine if ST Math improved motivation and engagement in males and females in the fourth and fifth grades. The information from this research could assist schools' administrators in determining if ST Math is worth the cost of the program, improves motivation and engagement, and has considerations to gender. Quantitative data that supports technology intervention to increase student motivation and engagement are significant so schools can make informed decisions.

Processes to Accomplish

Design

A quantitative, causal-comparative strategy was used in this study. Each hypothesis was constructed using a 2 x 2 between-group design. The independent variables for all four hypotheses included ST Math participation status (students participating in ST Math as intervention versus students not participating in ST Math as an intervention) and gender (male versus female). The dependent variable for Hypotheses 1 and 3 was positive student motivation as measured by the MES for fourth- and fifth-grade students from four Northwest Arkansas Schools. The dependent variable for Hypotheses 2 and 4 was positive student engagement as measured by the MES for fourth- and fifth-grade students from four Northwest Arkansas Schools.

Sample

Students' scores made up the sample for this study. Scores selected were from students attending two elementary schools in Northwest Arkansas. The students were chosen from the schools' populations to include students from all tier levels (Tiers 1, 2, and 3) of instruction. I used a stratified random sampling process and subdivided the students by school, by grade level, by ST Math participation, and by gender. One school participated in ST Math, and one school did not participate in ST Math. The sample consisted of 160 fourth-grade students (80 participating in ST Math as an intervention and 80 not participating in ST Math as an intervention) and 160 fifth-grade students (80 participating in ST Math as an intervention and 80 not participating in ST Math as an intervention). The gender was equally distributed in the sample (40 males and 40 females from each sample group). Both schools had similar demographics including race and socioeconomic status.

Instrumentation

The two dependent variables of this study were motivation and engagement. Data collected through a self-reported survey were used to assess students' motivation and engagement. Stephens (2015) stated that motivation and engagement are involved with the students' interests and enjoyment of school, which also could influence academic achievement. Teachers' attitudes and enjoyment in the delivery of instruction played a part in the students' motivation and engagement, as well. For students to learn effectively, they must be engaged at some degree or level. Motivation is defined as having the excitement or desire to participate in a given task, whereas engagement is active involvement in a task or lesson. Students who are motivated tend to become more engaged in the activity and have positive outcomes in learning.

The MES—Junior High (Elementary/Primary) survey was administered to the stratified sample. The MES—Junior High survey instrument was created by Martin (2015) from the University of Sydney and published by the Lifelong Achievement Group. Fredricks et al. (2011) reported that the MES had an internal consistency of .70-.87 (Cronbach's Alpha), a test-retest correlation of .61-.81, and passed the validity of construct and criterion-related measures. The instrument was developed for ages 9 through 13 as a self-reported questionnaire and contained measurements comprised of 11 subscales divided into four categories of motivational and engagement strengths and weaknesses.

This instrument was administered in classrooms by school staff after district approval was granted. The students in this study completed the survey to evaluate whether the classroom lessons with the technology intervention were motivating and engaging. Motivation was the dependent variable for Hypotheses 1 and 3, and engagement was the dependent variable for Hypotheses 2 and 4.

Data Analysis

To measure the first and third hypotheses, two 2 x 2 factorial analysis of variance (ANOVA) were conducted using ST Math participation and gender as the independent variables and motivation as the dependent variable. I conducted two 2 x 2 factorial ANOVAs for the second and fourth hypotheses with ST Math participation and gender as the independent variables and engagement as the dependent variable. To test the null hypotheses, I used a two-tailed test with a .05 level of significance. A Bonferroni correction was implemented to adjust the probability value because of the increased risk for Type I errors when performing multiple statistical tests. Because two samples were drawn, I used an adjusted significance level of .025 (.05/2).

CHAPTER II

REVIEW OF THE RELATED LITERATURE

This review provided an examination of literature related to instructional intervention and technology. Three major sections of this chapter include the following: Instructional Intervention, Gender, and Motivation and Engagement. Within the section of Instructional Intervention, research was reviewed on the evolution of intervention, explaining the reforms which have shaped the educational system; on RTI including each tier's description; special education and RTI; the role of technology and mathematics; and the ST Math Program. The second section of this review (Gender) focuses on the research related to the developmental levels and mathematical achievement in males and females. The final section dealing with motivation and engagement defines the two terms and reviews the relationships to student achievement

Instructional Intervention

Historical Overview

Education has progressed over time through the process of educational reforms from laws and acts related to improving the delivery of education. In 1647, the General Court of the Massachusetts Bay Colony declared that any town having at least fifty families needed an elementary school to teach children to read the Bible ("Historical Timeline," n.d.). One major reform movement led by Horace Mann, known as the father of American public schools, was to make school available to more children through tax collection to build and support schools ("Education Reform," n.d.). At this time, the belief was that all children needed to have access to education. These education reforms in early times made school attendance a requirement for children of certain ages.

The educational reforms approached many different aspects of education for children. Some reformers such as Thomas Gallaudet and Dr. Samuel Howe focused on teaching children who were hearing or visually impaired ("Education Reform," n.d.). The idea behind these movements was the forward thinking of educating all children. In 1957, a significant push for federal resources was directed toward education through the process of producing a more rigorous curriculum to better serve the gifted students by developing ideas that would help the country become more competitive (Fritzberg, n.d.). The notion of American students lagging in education was again brought into the spotlight with the 1983 publication of a federal report called *A Nation at Risk* (Fritzberg, n.d.). The American people were worried that the students of America could not compete with those from other countries.

Several presidents have attempted to increase funding for public education to improve quality. President Clinton and President Bush promoted statewide standards and assessments that all children should achieve (Fritzberg, n.d.). The No Child Left Behind Act (2002) was a part of President Bush's agenda to ensure every student performed at grade level. The purpose of this act was to close the achievement gaps, which caused school districts to increase intervention implementation for students who were performing below grade level and meeting the adequate yearly progress goals set to retain federal and state funding. President Obama also attempted to close the achievement gap with the Elementary and Secondary Education Act (Fritzberg, n.d.). President Obama's focus was on statewide standards referred to as the *Common Core Standards* (Fritzberg, n.d.). Education reform has been developed and amended over time to close the achievement gaps between students.

Response to Intervention and the Tiers

The Individuals with Disabilities Education Act of 2004 mandated a meaningful education for all students including those with disabilities. Out of this concept of meaningful education for all, the RTI framework was developed. Researchers developed RTI in the late 1970s to identify students with learning disabilities and providing support to students at risk ("Education for All," n.d.). RTI is a process where schools identify students at risk of failing and provide targeted teaching to acquire missing concepts of skills or can also include aspects of challenging experiences known as enrichment (Morin, 2014.; Lee, n.d.). The overarching goal of RTI is to provide instruction in small groups in the general education classroom to meet the individual needs of the students, whether the students need remediation or enrichment opportunities ("Education for All," n.d.; RTI Action Network, n.d.). Interventions needed to be timely and taught explicitly for the best results.

One comprehensive approach of RTI was embedding universal design for learning with the use of technology. The universal design for learning addressed the needs of the students through instructional planning that included the environmental influences to effectively meet the individual student's needs (Basham et al., 2010). These researchers addressed how to integrate the RTI framework with scientifically-based instructional strategies, universal design for learning, and the use of purposeful technology to provide a better support system to meet all students' needs.

In recent years, the focus of education has become less on teaching and more on student learning. The RTI Action Network (n.d.) stated, "RTI is designed for use when making decisions in both general education and special education, creating a well-integrated system of instruction and intervention guided by child-outcome data." (para. 1). In DuFour's (2004) professional learning communities, four questions guide every action teachers, administrators, and districts make: What do we expect our students to learn? How will we know our students are learning? How will we respond when students do not learn? How will we respond when students already know it? The data from student assessments are interpreted to differentiate instruction and provide needed interventions for student learning and student success in the RTI process.

Intervention models are often believed to be a pyramid design with each level or tier increasing in instructional intensity. The students' deficits or needs determine the tier of instruction required. The RTI Action Network (n.d.) described Tier 1 instruction as core instruction that is high quality and presented to all the students in the classroom. Data is collected to determine academic and behavior baseline information on each student. Approximately 75-80% of students in the classroom are expected to reach successful levels of competency at Tier 1 (Shapiro, n.d.). Tier 2 instruction is considered targeted intervention and includes small group instruction for about 10-20% of the students who are missing skills. These students continue to receive instruction in the regular education classroom, as well. Tier 3 instruction is the highest, most intensive level of intervention and is involves specialized and individualized instruction. Tier 3 instruction is implemented with approximately 5% of students (Shapiro, n.d.). If a student is still not making progress in this tier, then eligibility for special education services is sought.

Some essential elements of RTI include progress monitoring with assessment and an implementation process of interventions. Progress monitoring is a crucial RTI component to track the student's response to the intervention designed to close the gap in the learning (RTI Action Network, n.d.). Students in Tier 2 interventions generally receive less progress monitoring than students in Tier 3. Tier 2 interventions are usually monitored weekly or every other week, whereas Tier 3 interventions are monitored twice per week (Shapiro, n.d.). The purpose of the progress monitoring is to ensure the student is making progress and to assess if the intervention is working appropriately for the intended purpose.

For the struggling learner, one key difference between Tier 2 and Tier 3 is the way instruction is delivered. Tier 2 interventions are generally targeted instruction presented in small groups, where Tier 3 is delivered individually. Time spent in the interventions also varies from thirty minutes per day, three times a week for Tier 2 to thirty minutes per day, five times a week for Tier 3 (Brown, 2016; Shapiro, n.d.). Schools who have RTI teams that communicate and review data regularly tend to have a stronger understanding of the implementation of the RTI process.

One goal of the tiered system is that once a student becomes successful in Tier 2 or 3, the student moves to the lower tier with the possibility of remaining in Tier 1 classroom instruction. If a student fails to improve skills at one level of instruction, a higher or more intense level of instructional intervention may be necessary for the student. In some districts, Tier 3 intervention is associated with special education based on the individualized instruction concept (Kupzyk et al., 2012). To qualify for a referral of special education, a student must have undergone researched-based interventions; however, this process is not always followed. One key difference between a student in Tier 3 and a student in special education is the Individual Education Plan (IEP), which can provide many accommodations across parts of the student's school life in addition to the instructional process (Shapiro, n. d.). Data are reviewed when making effective decisions about a student's progress and to determine what is an appropriate tier of instruction.

Special Education and RTI

Education has often viewed RTI as an approach to early intervention and a method for identifying disabilities for students. Under the No Child Left Behind Act of 2001, the problem of chronic underachievement for students with disabilities became an increased focus. Special education needs to be thought of as a continuum of services for those students who are academically or behaviorally performing below the standards, to general education, and to those students who exceed standards (Raymond, 2014). Tilly (2008) reported that students with intensive instructional needs tended to be excluded from the RTI process. Interventions, whether for students with special needs or those with giftedness, needed to become skill-focused on individual needs, not programs or placement (Raymond, 2014; Tilly, 2008). Because a student is not making adequate progress with one type of intervention does not automatically mean that the student needs a referral for a comprehensive evaluation for special education services.

Clear communication, expectations, and training among faculty and staff related to interventions are essential. According to Utley and Obiakor (2015), targeted interventions need to include organizational systems, intervention practices, and use of data for the best results. Teachers and administrators need opportunities for training, for setting expectations, and for the design of the program within the school to become implemented. As an example, universal design for learning is an educational framework that assists with the development of flexible learning environments to accommodate for learning differences. The educational framework is often associated with students identified under the disability category of specific learning disabilities. Strangeman et al. (2006) compared RTI with universal design for learning. RTI was focused on making decisions about specialized interventions based on wheter students were *at risk* of success or failure; whereas, universal design was focused on making curriculum design decisions to improve success in the general curriculum (Strangeman et al., 2006). Teachers and administrators need systems in place to promote professional development within the RTI environment.

Providing robust instructional strategies at Tier 1 was essential to meet the needs of all students to reduce the number of students in need of interventions. Fuchs and Fuchs (2017) conducted a study on the RTI system that stressed the importance of screening accurately to ensure that students were not over identified when requiring upper-tiered interventions or referrals for special education services. Harn, Basaraba, Chard, and Fritz (2015) studied the impact of school-wide prevention efforts using academic and behavior support systems such as RTI. Their focus on implementing interventions with a multi-system approach addressed academics and social/emotional and behavioral interventions. The results indicated that an integrated system included academic interventionist or instructional coaches and behavior specialists to promote the development of students

(Harn et al., 2015). When team members worked together, more students' needs were met when the focus was on the whole child.

Research has been conducted to determine how states implement RTI. Previously, the discrepancy model was used in identifying students for learning disabled classification in special education, but with the reauthorization of IDEA, a student is currently required to receive scientific, researched-based interventions as a part of the evaluation process (Hoover et al., 2008). The discrepancy model became known as the *wait to fail model* because a student had to be one and a half to two grade levels below before he/she could qualify under the learning-disabled category. The RTI model had four advantages over the discrepancy model: early identification, risk model rather than deficits, reduction of identification biases, and focus on student outcomes (Hoover et al., 2008). According to Hoover et al., (2008) most states differed on the implementation of RTI. Each school had control over RTI implementation; therefore, interventions looked different in every school district.

Technology in the Classroom

Technology is a tool used by many districts to increase student achievement. Using digital curriculum and game-like lessons, teachers are seeing growth in mathematical understanding, as well as an increase in the percentage of students who meet or exceed growth projections (Smith, 2017). Interactive whiteboards have become a useful technology tool. One advantage of using an interactive whiteboard was increased student motivation. Using interactive whiteboards promoted student involvement in the lesson more than the traditional lecture format where the students' roles were to sit and listen to the lessons. Schools also used immediate response devices known as *clickers* to increase student engagement. Advantages to incorporating these devices are the automatic feedback to students, the anonymity of student responses, and the immediate feedback the teacher receives about students' needs so that instruction can be adjusted (Ozel et al., 2008). Assessment scores often drive school districts to look for innovative ways to improve instruction that increase student achievement.

Technology implementation should be systematically implemented to ensure success. Ozel et al. (2008) described the five phases for effective technology integration: determine relative benefit of technology integration, evaluate if the advantage takes place, design integrations and teaching strategies, prepare all aspects of the instructional environment including acceptable use policies, and teacher reflections to determine what worked well and what needed improvement. School districts should continue to search for innovative ways to implement technology and increase student achievement through technology.

Technology is now rooted in our daily operations. Integration of the Common Core Standards has caused technology to be a more significant priority in schools than in the past. Costley (2014) stated that technology had influenced students' learning by causing them to be more engaged through hands-on learning experiences. An advantage to using technology in the classroom is the varied levels of instruction that can be happening at the same time based on the student's individual needs. "Technology is capable of unlocking keys of learning with all students," noted Costley (2014, p. 8). With the increases in technological advances, the use of technology in schools is a natural progression to be included for better opportunities to learn and stay current with societal expectations.

Technology Intervention for Students with Special Needs

The word *technology*, many times, leads the mind to think of cutting-edge, high tech, transformational devices, but assistive technology has been available and used for students receiving special education for many years to support them with communication needs, hearing devices, and vision and mobility needs. This type of technology included simple communication switches to more advanced computerized devices such as augmented speech devices. These specific types of technologies have been a part of the student's IEP for many years, which has provided access to the free and appropriate education ensured by IDEA (U.S. Department of Education, 2004). These devices have often been cumbersome for students and were limited for use outside of the special education classroom (Lynch, 2016). With the advances in technology, tools like the iPad have replaced the older, more archaic augmented devices such as communication cards or text-to-speech boxes, making student support more portable, accessible, and high tech.

With the knowledge that students with special needs often require more support or scaffolding to be successful in learning concepts and with the increased use of technology in schools, researchers are now discovering technology-based solutions utilizing interventions for all students, not just for the most severe students (Smith & Okolo, 2010). One type of intervention that has worked for students with learning disabilities is graphic organizers. Graphic organizers assist students in organizing material in a more organized format to improve understanding. Many graphic organizers are software-based or web-based from companies like Inspiration, Kidspiration, and Webspiration (Smith & Okolo, 2010). These technology-based graphic organizers integrate many concepts needed to support students with learning disabilities by providing visual representations of instructional material. An added benefit of using a technology-based graphic organizer has been the flexibility and interactive aspect versus the traditional paper-type organizer. Teachers can electronically provide additional scaffolds by placing sentence frames into the organizer based on the student's individual needs. (Smith & Okolo, 2010). All students can use the technology-based graphic organizer, but those requiring extra support can receive this support without others being aware of the differences. Teaching students with special needs in remediation or enhancement require more individualized types of support, and technology-based supports are meeting these needs.

Every student in every tier, including students with disabilities, require direct instruction to learn basic skills. Direct instruction involves a structured and sequenced format where the teacher is explicitly teaching. This type of instruction includes drill and practice, student feedback, review teacher modeling, and progress monitoring for skill improvement (Smith & Okolo, 2010). Drill and practice activities or programs are ways that technology-based solutions are integrated with technology. Technology-based instruction programs have many built-in features that provide feedback to the student, as well as progress monitoring features that assist the teacher in monitoring the student's progress (Lynch, 2016; Smith & Okolo, 2010). All students require some direct instruction to acquire skills, but students with special needs may necessitate additional explicit instruction to grasp the same basic skills and concepts.

Roles and Types of Technology Used in Mathematics Intervention

Technology has been integrated into schools and daily life at an increasing rate. More companies are developing software and programs specifically designed for use in the classrooms from kindergarten to graduate school. These products are used for intervention or extensions of learning based on individual student's needs. Williams (2013) and Peterson (2012) investigated how mathematics instruction has evolved with the use of online and software-based programs to make learning more interactive and engaging while being challenging and fun. The purpose of the software, created in a game-like format, was to meet the students where they were in skills and to build on the existing concepts to higher concepts of understanding of the mathematics standards, eliminating gaps (Williams, 2013). The software that has been developed for elementary levels are more game-like, and as the grade level increased, the programs leaned more on tutorial-style programming. Innovation with the use of technology in classrooms is essential.

The increase in technological advances has affected classroom instruction. Technology-type tools have been used in mathematics classes for many years in the form of calculators. Now, social networks such as Facebook, wikis, or blogs are free communication software that teachers can use to provide modeling of how to solve mathematics problems in a step-by-step format to assist students and build an understanding of mathematical concepts (Allsopp, McHatton, & Farmer, 2010). These types of video clips can be viewed and paused as the student works the problems at a slower pace to grasp complex concepts. Many classrooms have incorporated computers, laptops, smartboards, and iPads as instructional tools.

Teachers want programs that engage students but also provide information about student performance. The technological instructional interventions need integration with the state standards and the lessons that are taught in the classroom. Dreambox Learning is an online elementary mathematics program that aligns to Common Core State Standards and is used as an intervention tailored to the student's individual needs (Williams, 2013). This type of program is beneficial because of the built-in scaffolds and sequencing that helps with pacing lessons for students. Many teachers have used a software program called IXL to supplement mathematics instruction. This program was initially developed as a website where teachers and learners could share customized study materials with gamification mechanics (Wikipedia contributors, 2019). IXL Math has more than 2,000 mathematics skills for algebra and geometry instructions for students in Grades K-8. (Wikipedia contributors, 2019; Williams, 2013). For this type of program, the school district is required to purchase a subscription. In addition to the previously mentioned software programs, Williams (2013) also cited these online resources or programs: Learning.com, iLearn Math, Carnegie Learning, Texas Instruments, Shmoop, Maple 16, and Wowzers. Each of these programs provided specific mathematics interventions that are interactive and engaging so students can learn different mathematical concepts and provided reports for teachers to monitor progress.

Today's students are living seamlessly with technology with instant access to information. Teachers are integrating more technology into their lessons to maintain students' attention. For many years, computers were employed for research projects, not direct instruction. By definition, *learning* means to acquire new information or knowledge by integrating the new information with previous knowledge or experiences ("Learning," 2018). Students have different personal or cultural experiences that have shaped their learning before entering school, which continues as they progress through the different grade levels. Due to the diversities of the students' backgrounds and learning styles, traditional teaching methods often fall short of meeting students' needs (Shin, Sutherland, Norris, & Soloway, 2012). Technology provides alternative methods to meet wide varieties of skills and learning styles. The use of technology in classrooms is relevant for students so they can keep pace with the world in which they live.

With today's students engrossed in technology, the integration of technology into classroom lessons could engage and motivate students to complete the assignments and improve achievement. As a part of the engagement, students need activities that allow them to experience productive struggle to aid in their conceptual understanding of skills, and the use of technology in the classroom could empower students and improve their learning (Smith, 2017). Carr (2012) conducted a study with a control group where one group used iPads as part of the 1:1 computing instruction in the mathematics class, and the other group used more traditional methods but incorporated collaborative learning games. According to the experiment, both groups performed equally well on the post-test. Therefore, the increase in both groups' scores might have been a result of the design of the games rather than the use of iPads. According to Shin et al. (2012), the evidence was insufficient that the use of technology positively influences teaching and learning; therefore, more research is necessary for areas such as motivation and engagement. Technology supports reflective thinking for meaningful learning in mathematics. Liang and Zhou (2009) conducted a study to explore the student experiences of using integrated technology system to study mathematics in two elementary schools. They discovered that learning through playing encouraged student self-exploration. The key to integrating technology in learning was not as much about how the information was presented but the degree to which the students were motivated to complete the work to achieve their personal goals (Liang & Zhou, 2009). Technology often makes the learning process playful and fun, supporting meaningful thinking and learning.

ST Math

Mathematics learning is reinforced through practice. Three types of mathematics learning are self-organized learning, reinforcement learning, and error-driven learning (Peterson, 2012). The learning that is most common in schools is the concept of reinforcement learning that involves rewards and consequences from acquiring new skills. According to Peterson (2012), the most powerful learning comes from error-driven learning. Spatial Temporal (ST) Math software was created nearly 20 years ago on the premise that students learned through trial and error and had the tutorial technique claim that this fits in the space-time continuum (Madda, 2015; ST Math, 2016). The ST Math software program was game-like with a mascot named JiJi who engaged and motivated students to solve mathematical problems through spatial-temporal representations, limited mathematical symbols, and technical terminology (Rutherford, Farkas, & Duncan, 2014). This type of learning encourages the student to undergo a trial and error to build an understanding of the concepts. Spatial Temporal Math was based on this premise.

With over 1.2 million students, 53,000 teachers, and 3,900 schools in 47 states implementing the ST Math program currently (ST Math, n.d.b.), a significant amount of information exists about ST Math's conceptual instruction. The ST Math program provides state-aligned standards, enhancement of core curricula, embedded assessments, detailed teacher reports and tracking, and visual and conceptual instruction (ST Math, n.d.c.) The program, primarily for kindergarten to sixth grade (with some programming into high school), is taught visually, removing issues with language. As an example, in a unit lesson where *tens* are taught, flowers are used to represent the concept of *tens* and petals represent the *ones* (Madda, 2015). In a 2016 WestEd study of over 150,000 students, the ST Math's effectiveness was validated. The study included 16 states and 474 schools of third, fourth, and fifth-grade data. A statistically significant difference was discovered between the ST Math group and the matched comparison group with the ST Math group scoring at or above proficient on state standardized assessments that consistently implemented ST Math, outgrowing similar schools in statewide rank by 14 percentile points (Wendt et al., 2016).

ST Math's success is grounded in spatial-temporal reasoning skills. *Spatial-temporal reasoning* is the ability to conceptualize three-dimensional relationships of objects through space and time to solve multi-step problems (Nisbet, 2012; "Spatial-temporal reasoning," 2018). Spatial-temporal reasoning is significant in many fields: mathematics, natural sciences, engineering, meteorology, and architecture. Spatial-temporal examples include (a) using a map to navigate through a town; (b) determining if a suitcase is suitable for packing for a trip; (c) combing hair while looking into a mirror; and (d) playing a video game that stimulates spatial-temporal ability (Johns Hopkins Center for Talented Youth, n.d.; Martin-Gutierrez, Martin-Dorta, Saorin, & Contero, 2009). The ST Math program's conceptual construction employs spatial-temporal reasoning.

Technology games provide many benefits to the students in addition to the interactive engagement; the games provide feedback with repetition of skills. The MIND Research Institute conducted research studies that focused on mathematics achievement using ST Math as a technology intervention in California schools to measure improvement on the California Standards Test (Wendt et al., 2014). According to Wendt et al., the students who received instruction where the ST Math program was implemented with integrity demonstrated significantly higher mean scores on the California Standards Test than those in the same grades that were not provided access to the program. With the increase of technology, many schools are beginning to incorporate different software programs into their curriculums to support learning and promote engagement.

In recent years, educators have started to include educational games in the classroom to increase student engagement. Mendez and del Moral (2015) conducted a study where video games were used in workshops as an educational tool to facilitate lessons in both mathematics and science. They noted these video games required the person playing to be engaged in problem-solving and making decisions for the game to continue, and the video game design included activities that stimulated cognitive flexible and creative thinking strategies. The video games fostered autonomy in learning and cooperative learning skills as they worked together to resolve conflicts in the game. According to this study, video games increased engagement and learning for students when the proper objectives were tied to the curriculum (Mendez & del Moral, 2015). When the objectives were tied to state standards, the students were engaged in playing and increased their skills while learning. Technology can promote engagement, but the focus needs to remain on learning.

For engagement to be meaningful, the motivation must be intrinsic. Wright (n.d.) described what student engagement looked like while students are actively learning with the ST Math program, noting that the line between being a game—the entertainment piece—and a math program is not visible. A puzzle format promotes intrinsic motivation as students are increasingly challenged to work through problems they may have never encountered, making their brains productively struggle (opportunities to fail and try again), and moving JiJi through the puzzle (ST Math, n.d.b.) Because ST Math builds upon the knowledge previously gained, the engagement is meaningful.

The purpose of this research was to determine if the ST Math program influenced student learning in regards to motivation and engagement. The ST Math (n.d.a.) program is a neuroscience-based mathematics instruction program utilizing visual animations in game-based learning for students in Grades Pre-K to 12. The principal emphasis of the program was founded on the brain's ability to hold visual information referred to as spatial-temporal reasoning (ST Math, 2016). ST Math (n.d.b.) is a digital program that assists struggling students' growth to proficiency and proficient students' growth to advanced. The program is designed to increase student engagement through solving tantalizingly puzzles which are intrinsically motivating. The challenging mathematical games support students creatively and build number sense instead of just memorizing facts. The ST Math program promotes a self-driven learning model and engagement in mathematics.

Gender

Gender differences and the influence on achievement has been researched for many years. Hyde and Mertz (2009) conducted a study that focused on gender differences related to culture and mathematics performance across diverse populations. Research results indicated that males and females similarly acquired early concepts in the preschool years through elementary; however, boys' mathematical skills increased faster than girls beginning around ages 12 or 13, causing a significant gender gap in high school performance (Hyde & Mertz, 2009; Rosselli, Ardila, Matute, & Inozemtseva, 2009). Hyde and Mertz's (2009) study results indicated that females scored slightly higher than males on computation in elementary and middle schools with no difference in high school, but with noted differences in complex problem-solving during high school. Linver, Davis-Kean, and Eccles (2002) indicated a decline in the gap of achievement on standardized test scores between males and females, but those females tended not to seek careers related to mathematics. Research on achievement gaps generally includes information about gender differences.

Gender differences may also have an impact on motivation and engagement. Wierzbitzki (2014) reported substantial differences in motivational forces between male and females. He noted that males were more motivated by measurable results of instrumental value; whereas, females were more motivated through acknowledgment, respect, or interpersonal relationships. According to research conducted by Yun Dai (2001), females scored higher in self-perceptions of verbal ability than males, and males scored higher than females in self-perceptions of capacity in mathematics. One reason females performed lower in the area of mathematics was related to their self-confidence (Azar, 2010). The research by Ajai and Imoko (2015) designated that the gender differences in mathematics teaching, learning, and achievement were linked to how each gender experienced the world through learning styles and societal positions. Researchers discovered gender differences in prosocial behavior or emotions, where females were viewed as more helpful, cooperative, and sympathetic than males (Cook & Cook, 2018).

Attitudes and self-concept about mathematics lead to motivation and engagement to varying degrees between different genders.

Children grow and learn at varying rates. Developmental milestones are expected during each phase of growth. According to Morin (n.d.), students that were in the fourth and fifth grades typically developed the ability to understand different points of views. Females tended to have their growth spurt between ages 9 and 11, while males do not experience their growth spurt until ages 11 and 12 (Morin, 2014). Morin (2014) noted that girls tended to demonstrate more insecurity, mood swings, or struggle with self-esteem than males at the fourth and fifth grades. Both genders at this age began to focus on building friendships and using social media (Morin, 2014). Females usually produced words at an earlier age than males, which influenced their language development and education acquisition in the language arts area, yet males began to outperform females in mathematical problem-solving during their adolescent years (Cook & Cook, 2018). Males and females reached developmental milestones that influence language and educational development at different ages.

Motivation and Engagement

Students need motivation and engagement in their learning processes. *Motivation* is the willingness to participate or something that causes a student to act, and *engagement* is the amount of attention a participant is emotionally involved or committed ("Engagement," 2018; Galloway, 2016; "Motivation," 2018). Galloway (2016) further described motivation as the *why* a person does something and engagement as the *what* that a person does. Martin et al. (2015) defined motivation as a student's drive or energy and engagement as the behaviors that follow from the drive or energy. Engagement is the commitment to the task and categorized into three areas: behavioral, emotional, and cognitive; whereas, motivation is best defined as interrelated beliefs and emotions that influence and direct behavior (Way, Reece, Bobis, Anderson, & Martin, 2015). Students benefit by being actively engaged in lessons, as well as being motivated to participate in lessons in order to learn more effectively.

Motivation and engagement can be measured using the Motivation and Engagement Wheel. Andrew Martin, an educational psychology professor at the University of New South Wales Sydney, developed a multi-factorial approach to student motivation and engagement (Lifelong Achievement Group, 2013). The wheel was comprised of 11 factors divided under four themes: positive motivation/thoughts (self-belief, valuing, learning focus), positive engagement/behaviors (planning, task management, persistence), negative motivation/thoughts (anxiety, failure avoidance, uncertain control), and negative engagement/behaviors (self-sabotage, disengagement). The wheel's conceptual development was the Motivation and Engagement Scale (MES). Measuring motivation and engagement using the MES can determine if programs promote student motivation and engagement.

Many teachers use some technology in the classroom environment but still do not see the value that educational games or technology offer when integrated into lessons. Chen (2003) and Smith and Cook (1992) determined that teachers' delivery methods were categorized into the guiding teacher, the facilitating teacher, and the interactive teacher. Guiding teachers observed and supported the students but did not interact with them during the lessons. Facilitating teachers engaged and interacted with the students during the lessons, but the students were still in charge of their learning. The interactive teacher was the most involved during the lessons, intervening or strategizing with students as they had difficulty with problems or situations. Teachers who were interactive even joined in learning and had competitions with the students. Rukavina, Zuvic-Butorac, Ledic, Milotic, & Jurdana-Sepic (2012) explored the concept of teaching approaches on the impact of motivation and engagement of students when pursuing educational opportunities in the field of mathematics, and according to this study, students preferred the workshop-style lessons to lecture-style lessons. When students were engaged in the learning process, they were more apt to make connections in learning and learn more about the topic. The instructional delivery affected motivation, engagement, and attitudes related to learning difficult concepts.

With the increase of technology use by students, teachers need to adapt lesson delivery methods to support student motivation and engagement. In the study conducted by Wells and Sheehey (2013), students increased their engagement when the teacher designed a lesson incorporating technology around students' interests. Campbell and Jane (2012) conducted a research study about students' attitudes in different learning environments. These conclusions indicated that students' attitudes were more favorable when learning was in an active technology environment than in the lecture-formatted classroom. They continued by noting that learning was a process in which students needed engagement for optimal learning to occur. When students learned through hands-on activities or discovery learning, they were making decisions based on their own experiences with learning, which developed a deeper understanding of concepts. This type of learning increased their intrinsic motivation of inquiry, according to Campbell and Jane (2012). Teachers must find ways to engage and motivate students to complete tasks so that learning can occur.

One way to motivate students is through game-like instruction techniques or strategies. These game-like motivational elements, also known as cognitive training tools, were studied to determine if game-like strategies made improvements to working memory skills (Katz, Jaeggi, Buschkuehl, Stegman, & Shah, 2014). The game-like features engaged students in the process while certain games built in motivational elements, and other games had these elements removed. Katz et al. (2014) conducted the study using an analysis of covariance to control for the variables to measure motivation and engagement of cognitive training. The results did not indicate significant influences on student motivation or performance when the motivation features were included versus when these were not included (Katz et al., 2014). However, according to Stephens (2015), motivation and engagement were predictors of students' enjoyment and interest in school. Students who were engaged in the learning tended to better behave in the classroom, usually achieved academically, demonstrated more effort, experienced more positive emotions, and paid more attention in the classroom (Stephens, 2015). Consequently, those students who were more engaged in learning also tended to be more motivated.

Motivation and engagement are essential for in-depth understanding and learning to occur. Students who were actively engaged in their learning had an increase in the motivational components of self-efficacy, intrinsic value, and test anxiety (Metallidou & Vlachou, 2007). In this research, self-efficacy was defined as one's belief in his/her ability to complete a task or be successful in an area of study. Therefore, if a student had a strong sense of self-efficacy, the student was likely more motivated to attempt the task. When an educational task was presented in a manner of relevance, students tended to approach the assignment differently than those who did not tie this to something in their lives or with personal goals. According to Metallidou and Vlachou (2007), students' decision-making processes influence their interests and intrinsic motivations based on the importance of doing well and how the task related to their specific goals versus the negative aspects of being engaged in the task.

Emotional reactions such as test anxiety can hurt student motivation and achievement. Metallidou and Vlachou (2007) noted that when students were not performing well academically, teachers often looked at two different aspects of the poor performance: skill and will. Did the students have the skills needed to complete the given task successfully? Were the students motivated to complete the task successfully? Both of these aspects are important for learning. The *skill* was considered the cognitive process, and the *will* was related to the motivational aspect, even determining the differences in motivational strategies used between male and female. They suggested that males tended to overestimate their abilities while females tended to underestimate their abilities in various domains. This concept relates to the idea that males perform better than females in mathematics courses. In general, females were rated as having higher test anxiety and having lower attitudes and beliefs about their mathematics abilities (Metallidou & Vlachou, 2007). The results of this study indicated that positive motivational beliefs and strategies such as self-efficacy led to better performance outcomes. Participation in learning increased the students' engagement, which promoted understanding and motivation to perform well on the task.

Conclusion

Instructional interventions, educational reform, technology and specific content-based programs, research on gender influences, and student motivation and engagement have changed the classroom over time. Interventions have evolved from the need for students to read the Bible in the 1600s to providing equal opportunities for all students and closing achievement gaps through the implementation of the tiered intervention of RTI. Technological devices have evolved from occasional calculator use in the classroom to daily instruction incorporating whiteboards, laptops, and specific programs designed for remediation to enrichment.

Many research studies have focused on the impact of classroom technology use on student motivation and engagement. Research on gender provided some differences in motivation and engagement in mathematics. The focus of this study was to determine if a difference existed between genders in motivation and engagement when participating in the ST Math program versus not participating in the program.

CHAPTER III

METHODOLOGY

The review of the literature indicated a trend in using technology in mathematics instruction to increase motivation and engagement as a tool for RTI. Interventions are systematic teaching strategies used to expand students' current level of knowledge, whether for remediation or enrichment. Teachers incorporate technology interventions in classrooms to improve student learning and aid in monitoring student progress. Many researchers have provided information about how integrating technology into instruction has revealed increased student participation, motivation, and engagement (Carr, 2012; Liang, & Zhou, 2009; Mendez & del Moral, 2015; Ozel et al., 2008; Smith, 2017). The purpose of this study was to determine if a difference existed by gender for fourth- and fifth-grade students in motivation and engagement by participating in the ST Math program versus students not participating in ST Math program. The hypotheses used in this study were as follows:

1. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools.
2. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus

students not participating on positive student engagement as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools.

3. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools.

4. No significant difference will exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools.

In this chapter I explained the research design, the sample, and the instrument used for measuring motivation and engagement of the students, as well as the data collection process. The limitations of the study were also included in this chapter.

Research Design

A quantitative, causal-comparative strategy was used in this study. This design was deemed appropriate due to the lack of control to manipulate or alter the variables based on the school setting and the comparison of the relationship of the independent and dependent variables (Leech, Barrett, & Morgan, 2015). A 2 x 2 factorial between-groups design was used to analyze the interaction effect and the main effects of gender and participation in ST Math regarding the dependent variables of motivation and engagement as measured by the MES. The study was two 2 x 2 factorial ANOVAs for each hypothesis. The independent variables for all four hypotheses were ST Math participation (students participating in ST Math as intervention versus students not participating in ST Math as an intervention) and gender (male versus female). The dependent variable for Hypotheses 1 and 3 was positive student motivation as measured by the MES for fourth- and fifth-grade students from two Northwest Arkansas Schools, respectively. The dependent variable for Hypotheses 2 and 4 was positive student engagement as measured by the MES for fourth- and fifth-grade students from two Northwest Arkansas Schools, respectively.

Sample

The fourth- and fifth-grade students' scores made up the two samples drawn for this study. The samples came from two accessible populations that included students in one school participating in ST Math and students in another school not participating in ST Math in Northwest Arkansas. The district representative and the principals of the schools approved the administration of the survey and the data collection. The fourth- and fifth-grade teachers at the schools administered the MES survey to the students, and two stratified random samples of scores were chosen from the two populations of fourth- and fifth-graders who participated in the survey and had scored in both the student motivation and the student engagement sections. Each grade-level sample consisted of scores from 40 females and 40 males for the fourth grade from each school and 40 females and 40 males for the fifth grade from each school. I entered the scores into an Excel spreadsheet for sorting purposes and transferred the coded data into the Statistical Package for the Social Sciences 25 (SPSS 25) software for analysis.

The two schools selected for the study had similar demographics related to socioeconomics and ethnicity. School A (participating in ST Math) had 97% of the student population receiving free and reduced lunches. School A consisted of students from Pre-K through the fifth grade with a total of 720 students in attendance. The race of School A was 44% White, 43% Hispanic, 9% Pacific Islander, and 4% other. In School A, both the fourth- and fifth-grade classes were taught in a self-contained format where the teachers taught all subjects. School B, with students who did not participate in ST Math, had 81% of the student population receiving free and reduced lunches. School B consisted of students from Pre-K through the fifth grade with 590 students in attendance. The race of School B was 31% White, 54% Hispanic, 8% Pacific Islander, and 7% other. In School B, the fourth-grade classes were taught in a self-contained format where the teachers taught all subjects, but the fifth-grade classes were departmentalized where teachers taught only specific subjects of reading and writing, mathematics, and science.

Instrumentation

The MES, which is a self-reported survey, was administered to the students at their respective schools. The scores were shared with me to provide data for the dependent variables in all four hypotheses. The data from the MES survey yielded a score for positive motivation and a score for positive engagement. Andrew Martin created the MES survey. Fredricks et al. (2011) reported that the MES has an internal consistency of .70-.87 (Cronbach's Alpha) with a test-retest correlation of .61-.81. They also noted that the MES has acceptable construct and criterion-related validity.

The MES—Junior High survey instrument, developed for students between the ages of 9 and 13, consisted of 11 subscales divided into four categories addressing positive and negative student motivation and positive and negative engagement (Martin, 2015). For this study, only six subscales and two categories were considered because of the focus on positive motivation and positive engagement only; the other five subscales and two categories related to negative motivation and negative engagement. The positive motivation subscales in this study were self-belief, learning focus, and valuing. Self-belief is how one perceives himself which often ties to self-confidence. A student who has strong self-belief feels he can meet challenges if he tries hard enough. Learning focus is how the student feels about the learning and the importance of comprehending what he is being taught. Valuing is the idea of relevance to the student's learning to real life. The positive engagement subscales in this study were persistence, planning, and task management. When a student demonstrates persistence, he continues to work on problems even though the problems may be challenging or difficult. Planning is how a student prepares for a task and how much he keeps track of progress made. Task management refers to how a student organizes his time and space to study. The results from the samples' scores for each of the three subcategories for positive motivation were combined and calculated, providing a value for positive motivation. The same was completed for the three subcategories for positive engagement.

The classroom teachers from the two schools administered the survey to all fourth- and fifth-grade students from all tiered intervention levels. The MES survey took each student approximately 20 minutes to complete. The complete survey contained 44 questions with a 5-point Likert-type scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In this study, 12 questions related specifically to positive motivation, and 12 questions related specifically to positive engagement were used. Each item was assigned a value ranging from 1 to 5. For calculation of a positive motivation score, the 12 questions were broken into subcategories with each category containing four items which were added to form a score out of 20. This sum was then multiplied by 5 to generate a raw score of 20 to 100. The same process was used to calculate a score for the 12 questions (four items in each subcategory) related to positive engagement. Only the scores of the students who completed the survey were analyzed to determine whether lessons involving technology interventions in a mathematics classroom affected positive student motivation and engagement. Motivation was the dependent variable for Hypotheses 1 and 3, and engagement was the dependent variable for Hypotheses 2 and 4 for this study. The cost to gain permission to use the survey instrument was approximately $100.

Data Collection Procedures

After the Institutional Review Board granted permission, I contacted the central office of the schools to obtain final approval. The surveys were sent to the principals of the two school, and they forwarded the surveys to the teachers in the two grade levels to administer to the students. During Spring 2018, the MES survey was administered to all of the fourth- and fifth-grade students at the two schools in Northwest Arkansas. The teachers administered the survey through an electronic Google form. The students responded to each question by using a 5-choice Likert-scale. The results of the samples' scores were forwarded to me through the response section of the Google form, and I randomly selected both samples from all the students who responded. The data were coded to identify the gender (male or female) and the school from which the student attended (*participating in ST Math* or *not participating in ST Math*). The student surveys were reviewed to verify the completion of the surveys, and any survey that was not complete was not used in the statistical analysis for this research. I entered the samples' scores into an Excel spreadsheet. The survey results were matched with each participant, and a score for positive motivation and a positive engagement were computed for each student's score. The electronic Google form was password protected and deleted after the calculations were completed. The identities of the samples were kept confidential through school-assigned identification numbers, and no names were included on the surveys. The surveys were completed voluntarily.

Analytical Methods

I used SPSS 25 to analyze the data from this study. The demographics of the two schools were reviewed and was determined that the race and socioeconomic status of the schools, in general, were similar. For testing each hypothesis, a 2 x 2 factorial between-groups ANOVA was implemented. A two-tailed test with a .05 level of significance was used for statistical analysis. I used the population's scores in the study. A Bonferroni correction was conducted to adjust the probability value because of the increased risk for Type I errors when performing multiple statistical tests. Because two samples were drawn, I used an adjusted significance level of .025 (.05/2). Homogeneity of variances was checked using Levene's statistic. The samples' scores were collected and coded by gender (i.e. male and female), grade level (i.e. fourth and fifth grade), and school type (i.e. participating or not participating in ST Math).

Hypothesis 1 was analyzed with a 2 x 2 factorial between-groups ANOVA using participation in ST Math as an intervention for mathematics and gender as the independent variables, and positive student motivation as measured by the MES was used as the dependent variable for the fourth-grade students. Hypothesis 2 was analyzed with a 2 x 2 factorial between-groups ANOVA using participation in ST Math as an intervention for mathematics and gender as the independent variables, and positive student engagement as measured by the MES was used as the dependent variable for the fourth graders. Hypothesis 3 was analyzed with a 2 x 2 factorial between-groups ANOVA using participation in ST Math as an intervention for mathematics and gender as the independent variables, and positive student motivation as measured by the MES was used as the dependent variable for the fifth graders. Hypothesis 4 was analyzed with a 2 x 2 factorial between-groups ANOVA using participation in ST Math as an intervention for mathematics and gender as the independent variables, and positive student engagement as measured by the MES was used as the dependent variable for the fifth-grade students.

Limitations

The following were limitations identified in this study. First, the consistency with which the teachers used the ST Math program could skew the data if not implemented with fidelity across classrooms and grade levels. The teachers that implemented the ST Math underwent specialized training on how to implement the program for optimal student growth. The students were to use the program for at least 20 minutes 3 times per week. The teacher’s role during the intervention was to monitor students and assist any struggling ones. If the teacher was not actively monitoring the students and their progress, the students could become frustrated to the point of giving up. Another common occurrence when students become frustrated was *level canceling* or repeated *exiting* from the program.

Second, the possibility that more than one type of intervention for mathematics could have been used at one or both of the schools. If schools were implementing more than one technology program as interventions for mathematics, the data results would not isolate differences attributed to ST Math.

Third, due to the design of the study, a causal-comparative strategy, I was not able to assign the students randomly to groups in order to gather the scores. In addition, because of the type of study, I could not manipulate one or more of the independent variables. Since I could not manipulate the independent variables, the possibility that the groups were not equivalent, causing an internal validity threat for the study. One internal validity threat was whether a relationship existed between the independent and dependent variables. An external validity threat was whether the results could be generalized to other groups that were not in a controlled group.

Fourth, the time of the school year in which the survey was administered could also be a limitation. The survey was administered at the end of the school year. By the end of the school year, the students and the teachers have completed state assessments, and the intensity or energy of the students and teachers could be diminished. Students and teachers are preparing for summer break, so they may not have seriously committed their efforts to the survey.

Fifth, the limited number of participants was also noted as a limitation. The survey was voluntary; therefore, some teachers chose not to administer the survey, or the students chose not to complete the survey. The sample size was smaller than anticipated due to the lack of return in the responses. The limited participants could be due to the timing that the survey was administered.

Sixth, the samples' scores were self-reported on the positive motivation and positive engagement questions from the survey. I cannot affirm that all participants filled out the survey with reliability. When a survey on self-reflection is administered, some individuals may have answered the questions in a manner that elevated themselves to be viewed more favorably, or if a person had low self-esteem or self-concept, he may have rated himself lower than what would be accurate.

Every effort was used to ensure that I was unbiased in the study. The instrument selected to measure the positive student motivation and positive student engagement had important research supporting the validity of the survey. The results from this study will provide the reader information as to whether the use of the ST Math program as a mathematics intervention versus not using a specified technology program increased positive student motivation and positive student engagement.

CHAPTER IV

RESULTS

The purpose of this study was to determine if participation in the ST Math program as an intervention increased students' positive motivation and engagement from two schools in Northwest Arkansas as measured by the MES survey. The independent variables in this study were participation status in ST Math and gender. The dependent variables were motivation for Hypotheses 1 and 3 and engagement for Hypotheses 2 and 4 as measured by the MES survey. The descriptive statistics are included to provide a broader understanding of the participants' scores in the study.

Analytical Methods

I conducted a quantitative non-experimental analysis with a 2 x 2 between-groups design. The SPSS 25 software was used to analyze and interpret the data (Leech et al., 2015). The data from the survey were coded for the four hypotheses: gender (1 = male, 0 = female), grade level (1 = fourth grade, 0 = fifth grade), and participation status in ST Math as a mathematical intervention (1 = participation, 0 = no participation). The data were de-identified, so I did not receive any names, only grade levels, gender, and Likert-type scores on the survey to ensure students confidentiality. The scores from 320 students enrolled in two schools in Northwest Arkansas (1 school participating and 1 school not participating in ST Math) were analyzed using four 2 x 2 factorial between-groups ANOVAs. Histograms were used to check for assumptions of normality due to the larger sample sizes involved with the independent variables of gender and participation status in ST Math on the dependent variables of positive motivation and engagement. Homogeneity of variances was checked with the Levene's test of variance. Assumptions were checked before running the statistical test to ensure that the proper test was selected for the analysis.

Hypothesis 1

Hypothesis 1 stated no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools. Data were screened for entry errors and missing values, with none being found. The assumptions for factorial ANOVA, including independent observations, homogeneity of variances, outliers, and normal distributions of the dependent variable for each group were checked. Histograms were used to check normality of gender and participation status in ST Math with the dependent variable of positive motivation on the MES. Table 1 displays the group means and standard deviations.

Table 1

Means, Standard Deviations, and Number for Positive Student Motivation by ST Math Participation Status and Gender

Gender	ST Math Participation Status	*M*	*SD*	*n*
Female	No	50.58	6.79	40
	Yes	51.13	7.44	40
	Total	50.85	7.09	80
Male	No	46.28	9.21	40
	Yes	48.18	8.45	40
	Total	47.23	8.83	80
Total	No	48.43	8.33	80
	Yes	49.65	8.05	80
	Total	49.04	8.19	160

Levene's test of equality of variances was conducted within ANOVA and indicated that homogeneity of variances across groups was not significant, $F(3, 156) = 1.77$, $p = .156$; therefore, the assumption of homogeneity of variance was not violated. No extreme outliers in the data existed. A 2 x 2 factorial ANOVA was performed to test the interaction effect between ST Math participation status and gender on positive student motivation. The results of the ANOVA are displayed in Table 2.

Table 2

Factorial Analysis of Variance Results for Positive Student Motivation as a Function of ST Math Participation Status and Gender

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Participation Status	60.03	1	60.03	0.93	.336	0.006
Gender	525.62	1	525.62	8.16	.005	0.050
Participation*Gender	18.23	1	18.23	0.28	.596	0.002
Error	10053.90	156	64.45			

R Squared = .057, Adjusted *R* Squared = .039.

The results revealed no significant interaction effect between ST Math participation status and gender, $F(1, 156) = 0.28$, $p = .596$, $ES = 0.002$. Therefore, ST Math participation status and gender did not combine to affect the positive student motivation of fourth-grade students significantly. Given there was no significant interaction between the variables of ST Math participation status and gender, the main effect of each variable was examined separately. The main effect for ST Math participation status was not significant, $F(1, 156) = 0.93$, $p = .336$, $ES = 0.006$. However, the main effect for gender was significant, $F(1, 156) = 8.16$, $p = .005$, $ES = 0.050$. This result has a small effect size (Cohen, 1988). Figure 1 shows the means for Grade 4 positive student motivation as a function of ST Math participation status and gender.

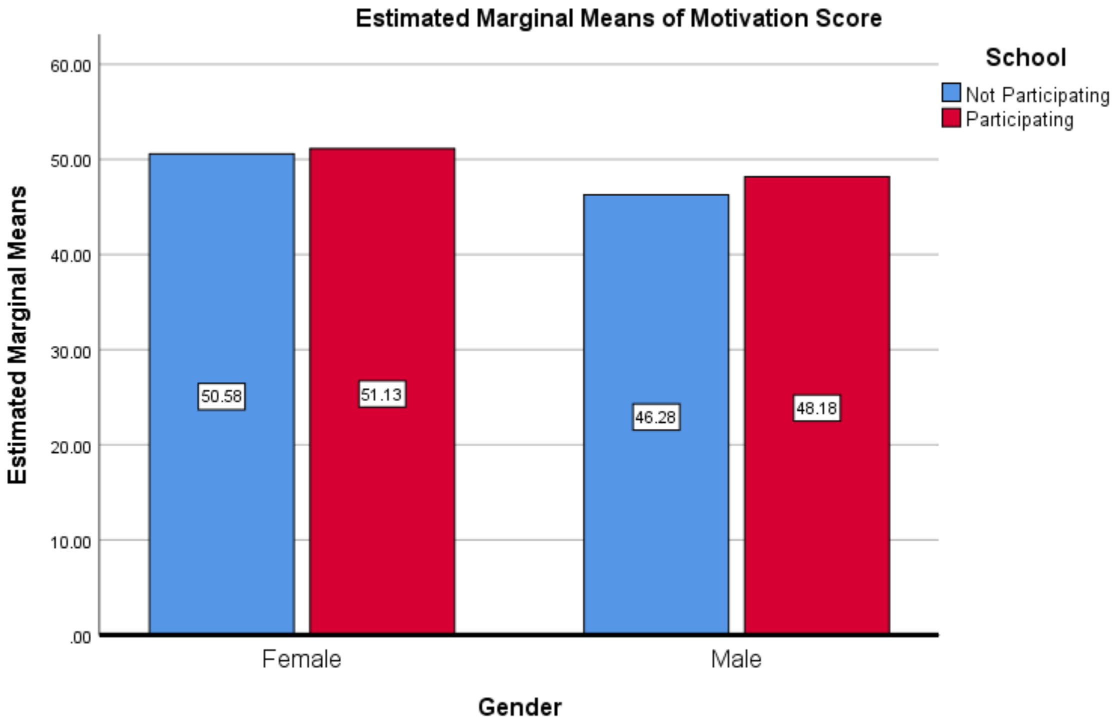

Figure 1. Means for positive student motivation as a function of ST Math participation status and gender for fourth grade.

On the one hand, the mean of the ST Math participation group (*M* = 49.65, *SD* = 8.05) was not significantly different compared to the mean of the group not participating in ST Math (*M* = 48.43, *SD* = 8.33). Overall, those in the participation group, regardless of their gender, did not score differently on positive student motivation than the group not participating. On the other hand, Figure 1 demonstrates that regardless of ST Math participation status, the main effect of gender was significant. After examining the data, the mean of the females (*M* = 50.85, *SD* = 7.09) was significantly higher compared to the mean of the males (*M* = 47.23, *SD* = 8.83). Overall, females scored higher than males on positive student motivation whether they participated in the ST Math program as an intervention or not. In summary, there was not enough evidence to reject the null hypothesis for the interaction effect or the main effect of ST Math participation status. However, the null hypothesis for the main effect of gender was rejected.

Hypothesis 2

Hypothesis 2 stated no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fourth-grade students in Northwest Arkansas elementary schools. Data were screened for entry errors and missing values, with none being found. The assumptions for factorial ANOVA, including independent observations, homogeneity of variances, outliers, and normal distributions of the dependent variable for each group were checked. Histograms were used to check normality of gender and participation status in ST Math with the dependent variable of positive engagement on the MES. Table 3 displays the group means and standard deviations.

Table 3

Means, Standard Deviations, and Number for Positive Student Engagement by ST Math Participation Status and Gender

Gender	ST Math Participation Status	*M*	*SD*	*n*
Female	No	52.40	5.62	40
	Yes	51.58	6.10	40
	Total	51.99	5.84	80
Male	No	46.70	8.43	40
	Yes	48.05	8.01	40
	Total	47.37	8.20	80
Total	No	48.55	7.68	80
	Yes	49.81	7.29	80
	Total	49.68	7.46	160

Levene's test of equality of variances was conducted within ANOVA and indicated that homogeneity of variances across groups was not significant, $F(3, 156) = 2.10$, $p = .102$; therefore, the assumption of homogeneity of variance was not violated. No extreme outliers in the data existed. A 2 x 2 factorial ANOVA was performed to test the interaction effect between ST Math participation status and gender on positive student motivation. The results of the ANOVA are displayed in Table 4.

Table 4

Factorial Analysis of Variance Results for Positive Student Motivation as a Function of ST Math Participation Status and Gender

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Participation	2.76	1	2.76	0.05	.816	0.000
Gender	851.01	1	851.01	16.68	.000	0.097
Participation*Gender	47.31	1	47.31	0.93	.337	0.006
Error	7957.67	156	51.01			

R Squared = .102, Adjusted *R* Squared = .084

The results revealed no significant interaction effect between ST Math participation status and gender, $F(1, 156) = 0.93$, $p = .337$, $ES = 0.006$. Therefore, ST Math participation status and gender did not combine to affect the positive student engagement of fourth-grade students significantly. Given there was no significant interaction between the variables of ST Math participation status and gender, the main effect of each variable was examined separately. The main effect for ST Math participation status was not significant, $F(1, 156) = 0.05$, $p = .816$, $ES = 0.000$. However, the main effect for gender was significant, $F(1, 156) = 16.68$, $p = .000$, $ES = 0.097$. This result has a medium effect size (Cohen, 1988). Figure 2 shows the means for Grade 4 positive student engagement as a function of ST Math participation status and gender.

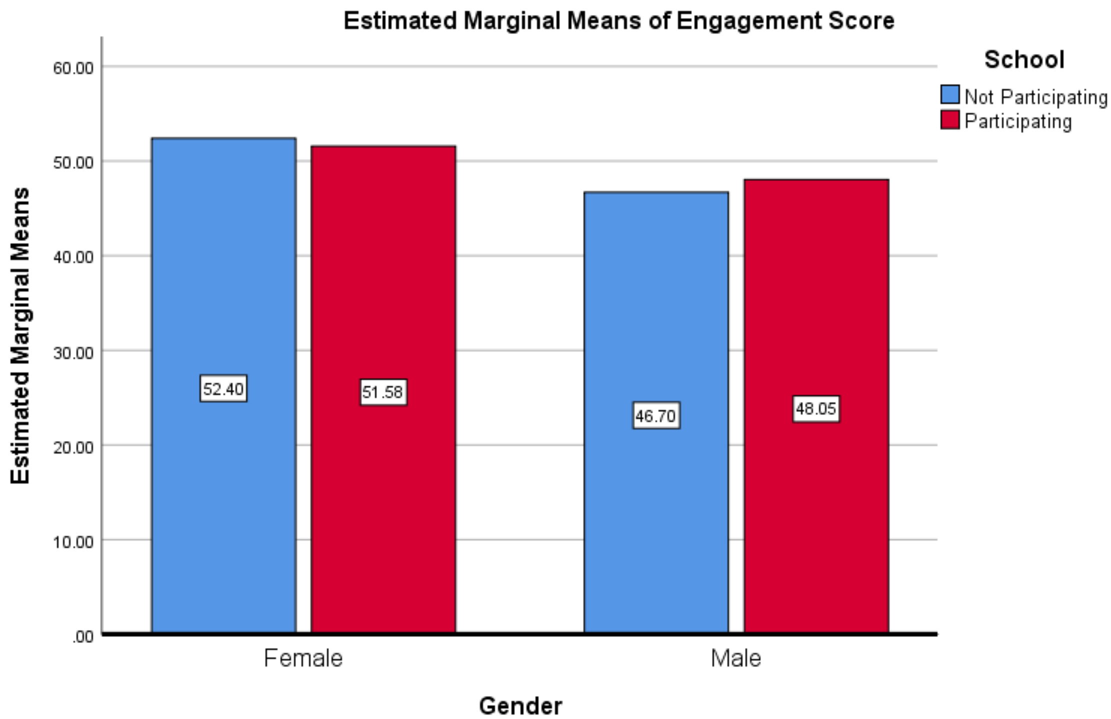

Figure 2. Means for positive student engagement as a function of ST Math participation status and gender for fourth grade.

On the one hand, the mean of the ST Math participation group (*M* = 49.81, *SD* = 7.29) was not significantly different compared to the mean of the group not participating in ST Math (*M* = 49.55, *SD* = 7.68). Overall, those in the participation group, regardless of their gender, did not score differently on positive student engagement than the group not participating. On the other hand, Figure 2 demonstrates that regardless of ST Math participation status, the main effect of gender was significant. After examining the data, the mean of the females (*M* = 51.99, *SD* = 5.84) was significantly higher compared to the mean of the males (*M* = 47.38, *SD* = 8.20). Overall, females scored higher than males on positive student engagement whether they participated in the ST Math program as an intervention or not. In summary, there was not enough evidence to reject the null hypothesis for the interaction effect or the main effect of ST Math participation status. However, the null hypothesis for the main effect of gender was rejected.

Hypothesis 3

Hypothesis 3 stated no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools. Data were screened for entry errors and missing values, with none being found. The assumptions for factorial ANOVA, including independent observations, homogeneity of variances, outliers, and normal distributions of the dependent variable for each group were checked. Histograms were used to check normality of gender and participation status in ST Math with the dependent variable of positive motivation on the MES. Table 5 displays the group means and standard deviations.

Table 5

Means, Standard Deviations, and Number for Positive Student Motivation by ST Math Participation Status and Gender

Gender	ST Math Participation Status	*M*	*SD*	*n*
Female	No	49.15	6.98	40
	Yes	50.33	6.56	40
	Total	49.74	6.76	80
Male	No	50.18	7.19	40
	Yes	48.18	8.76	40
	Total	49.18	8.03	80
Total	No	49.66	7.06	80
	Yes	49.25	7.77	80
	Total	49.46	7.40	160

Levene's test of equality of variances was conducted within ANOVA and indicated that homogeneity of variances across groups was not significant, $F(3, 156) = 0.97$, $p = .407$; therefore, the assumption of homogeneity of variance was not violated. No extreme outliers in the data existed. A 2 x 2 factorial ANOVA was performed to test the interaction effect between ST Math participation status and gender on positive student motivation. The results of the ANOVA are displayed in Table 6.

Table 6

Factorial Analysis of Variance Results for Positive Student Motivation as a Function of ST Math Participation Status and Gender

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Participation	6.81	1	6.81	0.12	.726	0.001
Gender	12.66	1	12.66	0.23	.632	0.001
Participation*Gender	100.81	1	100.81	1.83	.178	0.012
Error	8589.43	156	55.06			

R Squared = .014, Adjusted *R* Squared = .005.

The results revealed no significant interaction effect between ST Math participation status and gender, $F(1, 156) = 1.83$, $p = .178$, $ES = 0.012$. Therefore, ST Math participation status and gender did not combine to affect the positive student motivation of fifth-grade students significantly. Given there was no significant interaction between the variables of ST Math participation status and gender, the main effect of each variable was examined separately. The main effect for ST Math participation status was not significant, $F(1, 156) = 0.12$, $p = .726$, $ES = 0.001$. Similarly, the main effect for gender was not significant, $F(1, 156) = 0.23$, $p = .632$, $ES = 0.001$. Figure 3 indicates the means for Grade 5 positive student motivation as a function of ST Math participation status and gender.

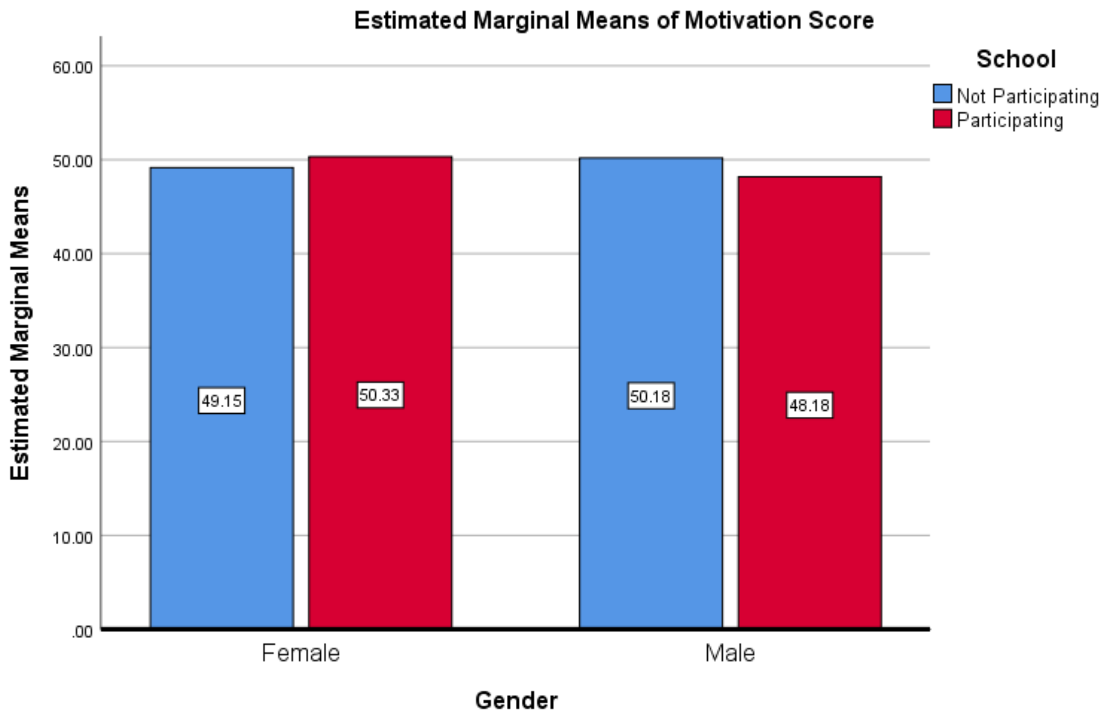

Figure 3. Means for positive student motivation as a function of ST Math participation status and gender for fifth grade.

Figure 3 indicates that the mean of the ST Math participation group (*M* = 49.25, *SD* = 7.77) was not significantly different compared to the mean of the group not participating in ST Math (*M* = 49.66, *SD* = 7.06). Overall, those in the participation group, regardless of their gender, did not score differently on positive student motivation than the group not participating. In the same vein, the mean of the males (*M* = 49.18, *SD* = 8.03) was not significantly different compared to the mean of the females (*M* = 49.74, *SD* = 6.76). Overall, females, regardless of their ST Math participation status, did not score differently on positive student motivation than the males. In summary, there was not enough evidence to reject the null hypothesis for the interaction effect. Likewise, the null hypotheses for both the main effect of ST Math participation status and the main effect of gender were retained.

Hypothesis 4

Hypothesis 4 stated no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fifth-grade students in Northwest Arkansas elementary schools. Data were screened for entry errors and missing values, with none being found. The assumptions for factorial ANOVA, including independent observations, homogeneity of variances, outliers, and normal distributions of the dependent variable for each group were checked. Histograms were used to check normality of gender and participation status in ST Math with the dependent variable of positive engagement on the MES. Table 7 displays the group means and standard deviations.

Table 7

Means, Standard Deviations, and Number for Positive Student Motivation by ST Math Participation Status and Gender

Gender	ST Math Participation Status	*M*	*SD*	*n*
Female	No	50.35	8.21	40
	Yes	50.02	6.76	40
	Total	50.19	7.47	80
Male	No	50.60	5.83	40
	Yes	49.22	6.91	40
	Total	49.91	6.39	80
Total	No	50.48	7.08	80
	Yes	49.63	6.80	80
	Total	50.05	6.93	160

Levene's test of equality of variances was conducted within ANOVA and indicated that homogeneity of variances across groups was not significant, $F(3, 156) = 0.59$, $p = .622$; therefore, the assumption of homogeneity of variance was not violated. No extreme outliers in the data existed. A 2 x 2 factorial ANOVA was performed to test the interaction effect between ST Math participation status and gender on positive student engagement. The results of the ANOVA are displayed in Table 8.

Table 8

Factorial Analysis of Variance Results for Positive Student Engagement as a Function of ST Math Participation Status and Gender

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Participation	28.90	1	28.90	0.59	.442	0.004
Gender	3.03	1	3.03	0.06	.804	0.000
Participation*Gender	11.03	1	11.03	0.23	.635	0.001
Error	408440.00	316	48.70			

R Squared = .006, Adjusted *R* Squared = .014

The results revealed no significant interaction effect between ST Math participation status and gender, $F(1, 156) = 0.23$, $p = .635$, $ES = 0.001$. Therefore, ST Math participation status and gender did not combine to affect the positive student engagement of fifth-grade students significantly. Given there was no significant interaction between the variables of ST Math participation status and gender, the main effect of each variable was examined separately. The main effect for ST Math participation status was not significant, $F(1, 156) = 0.59$, $p = .442$, $ES = 0.004$. Similarly, the main effect for gender was not significant, $F(1, 156) = 0.06$, $p = .804$, $ES = 0.000$. Figure 4 shows the means for Grade 5 positive student engagement as a function of ST Math participation status and gender.

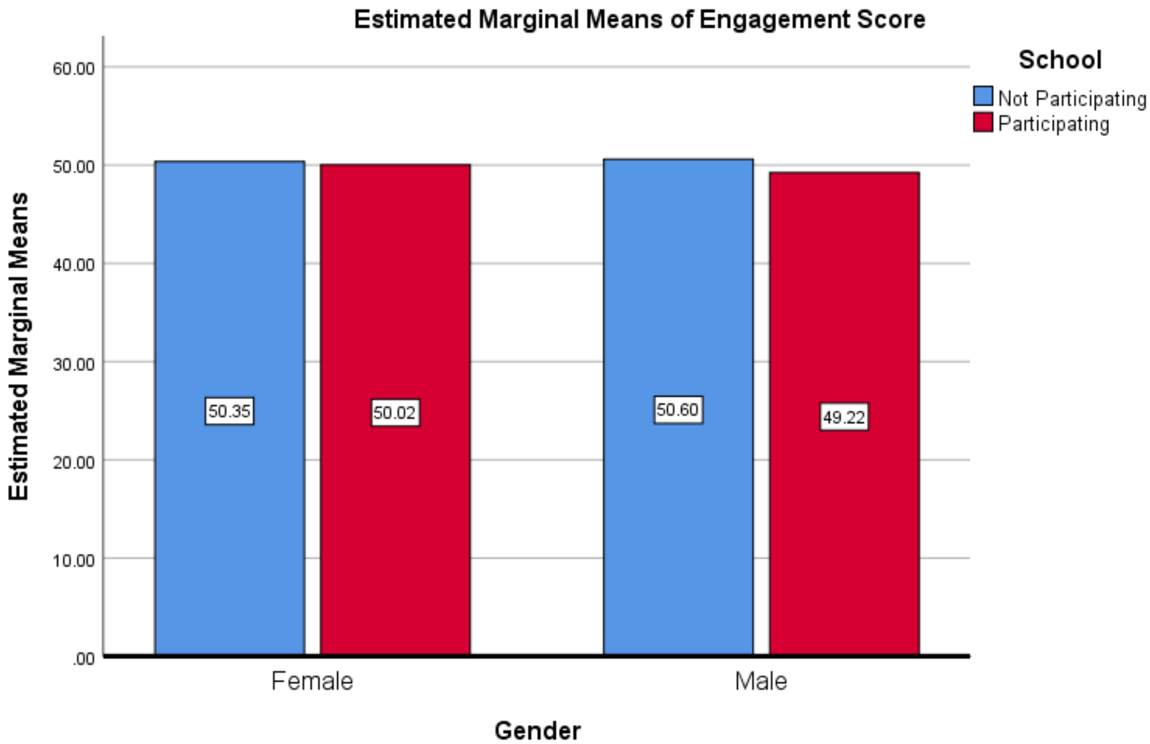

Figure 4. Means for positive student engagement as a function of ST Math participation status and gender for fifth grade.

Figure 4 indicates that the mean of the ST Math participation group (*M* = 49.63, *SD* = 6.80) was not significantly different compared to the mean of the group not participating in ST Math (*M* = 50.48, *SD* = 7.08). Overall, those in the participation group, regardless of their gender, did not score differently on positive student motivation than the group not participating. In the same vein, the mean of the males (*M* = 49.91, *SD* = 6.39) was not significantly different compared to the mean of the females (*M* = 50.19, *SD* = 7.47). Overall, females, regardless of their ST Math participation status, did not score differently on positive student motivation than the males. In summary, there was not enough evidence to reject the null hypothesis for the interaction effect. Likewise, the null hypotheses for both the main effect of ST Math participation status and the main effect of gender were retained.

Summary

The purpose of this study was to determine the effects of ST Math participation status and gender on positive student motivation and engagement for students in Grades 4 and 5 in two Northwest Arkansas elementary schools. Table 9 summarizes the results of the interaction and main effects of the four hypotheses.

Table 9

Summary of Statistically Significant Results for Hypotheses 1-4

	Positive Student Motivation		Positive Student Engagement	
	p			
	H_o1	H_o3	H_o2	H_o4
Variables	Grade 4	Grade 5	Grade 4	Grade 5
ST Math Part.*Gender	.596	.178	.337	.635
ST Math Part.	.336	.726	.816	.442
Gender	.005*	.632	.000**	.804

$^*p \leq .05$, $^{**}\ p \leq .001$

Overall, the results indicated no significant interaction between ST Math participation status and gender on positive student motivation and positive student engagement as measured by the MES for the Northwest Arkansas schools. Turning to the main effect of ST Math participation status, regardless of gender, the results indicated no significant effect on motivation and engagement across both grade levels. In examining the main effect of gender, regardless of ST Math participation status, findings were mixed. For fifth-grade students, gender did not significantly affect students' motivation or engagement scores. However, for the fourth-grade students, gender did influence motivation and engagement scores. Overall, females scored significantly higher in positive motivation and engagement compared to males. Positive motivation had a small effect size, and positive engagement had a medium effect size.

CHAPTER V

DISCUSSION

Educational reform has brought change to how instruction and intervention are taught and delivered in schools. With the No Child Left Behind Act (2002), school districts have increased intervention implementation in an attempt to close student achievement gaps. As a result, in 1970, the RTI framework was developed to identify student interventions for remediation and enrichment ("Education for All," n.d.). Increasingly, technology has supported student learning. In their research, Ozel et al. (2008) and Smith (2017) noted that technology integration had increased student motivation and engagement. Liang and Zhou (2009) focused on how learning through game-type instruction with technology for mathematics increased student motivation when completing assignments and achieving personal goals. Costley (2014) explained how students were more engaged through hands-on learning experiences with technology, which had a positive effect on student learning. This study attempted to determine if the use of the ST Math program increased student motivation and engagement. This chapter provided a summary of the findings related to each hypothesis. Based on these findings, this chapter includes conclusions, implications, and recommendations for potential practice or policy and future research considerations.

Conclusions

For Hypotheses 1 and 3, two 2 x 2 factorial ANOVAs were conducted using ST Math participation and gender as the independent variables and student motivation as the dependent variable. For Hypotheses 2 and 4, I conducted two 2 x 2 factorial ANOVAs with ST Math participation and gender as the independent variables and student engagement as the dependent variable. Two grade levels were represented, the fourth grade and fifth grade, in this study. Hypotheses 1 and 2 focused on fourth-graders' scores on positive motivation and positive engagement, and Hypotheses 3 and 4 focused on fifth-grade students' scores in the same areas.

Hypothesis 1

Hypothesis 1 stated that no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fourth-grade students in two Northwest Arkansas elementary schools. The results indicated that the interaction between ST Math participation and gender on the motivation for the fourth graders was not significant. Because no statistical significance existed, the null hypothesis for the interaction was retained. Similarly, the results for the main effect of ST Math participation indicated no statistical significance; therefore, the null hypothesis for the main effect of participation could not be rejected. Even though the mean score for motivation for the fourth graders participating in the ST Math program as an intervention for mathematics, regardless of gender, was slightly higher compared to those students not participating in the ST Math program, the difference was not statistically significant.

In contrast, the main effect of gender yielded a statistical difference for the fourth-grade students on motivation. Thus, the null hypothesis for the main effect of gender was rejected. Female students, regardless of ST Math participation status, scored significantly higher, on average, on motivation compared to their male counterparts. Therefore, the overall results indicated insufficient evidence to reject the null hypothesis for the interaction effect or the main effect of ST Math participation status. However, the main effect of gender indicated enough evidence to reject the null hypothesis.

Hypothesis 2

Hypothesis 2 stated that no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fourth-grade students in two Northwest Arkansas elementary schools. The results indicated that the interaction between ST Math participation status and gender on engagement for the fourth graders was not significant. Because no statistical significance existed, the null hypothesis for the interaction was retained. Similarly, the results for the main effect of ST Math participation indicated no statistical significance; therefore, the null hypothesis for the main effect of participation could not be rejected. Even though the mean score for engagement for the fourth graders participating in the ST Math program as an intervention for mathematics, regardless of gender, was slightly higher compared to those students not participating in the ST Math program, the difference was not statistically significant. However, a statistical difference existed for the main effect of gender for the fourth-grade students on engagement; therefore, the null hypothesis for the main effect of gender was rejected. The females, regardless of ST

Math participation status, scored significantly higher on engagement, on average, compared to the males in the study. Therefore, the overall results indicated insufficient evidence to reject the null hypothesis for the interaction effect or the main effect of ST participation status. However, the main effect of gender was statistically significant, and the null hypothesis was rejected.

Hypothesis 3

Hypothesis 3 stated that no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student motivation as measured by the MES for fifth-grade students in two Northwest Arkansas elementary schools. Because the interaction result for ST Math participation and gender on motivation was not statistically significant, the null hypothesis for the interaction could not be rejected for the fifth graders. Regarding ST Math participation status, regardless of gender, the results indicated no statistical significance on motivation for the fifth graders. The null hypothesis, therefore, was retained for the main effect of ST Math participation. The mean scores for motivation for the fifth-grade students participating in the ST Math program as an intervention for mathematics and the students not participating in ST Math were almost identical.

In addition, when gender was analyzed separately, regardless of ST Math participation status, no statistical significance existed; therefore, the null hypothesis for the main effect of gender could not be rejected. Again, the mean scores of the males and the females were almost identical. Therefore, the overall results indicated insufficient evidence to reject the null hypotheses for the interaction effect, the main effect of ST Math participation status, and the main effect of gender.

Hypothesis 4

Hypothesis 4 stated that no significant difference would exist by gender between students participating in ST Math technology as an intervention in mathematics classrooms versus students not participating on positive student engagement as measured by the MES for fifth-grade students in two Northwest Arkansas elementary schools. The results indicated that the interaction between ST Math participation status and gender on engagement for the fifth graders was not significant. Because no statistical significance existed, the null hypothesis for the interaction was retained. Similarly, the results for the main effect of ST Math participation indicated no statistical significance; therefore, the null hypothesis for the main effect of participation could not be rejected. Even though the mean score for engagement for the fourth graders not participating in the ST Math program as an intervention for mathematics, regardless of gender, was slightly higher compared to those students participating in the ST Math program, the difference was not statistically significant.

Similarly, when gender was analyzed separately, regardless of ST Math participation status, no statistical significance existed on engagement; therefore, the null hypothesis for the main effect of gender could not be rejected. Again, the mean scores of the males and the females were almost identical. Therefore, the overall results indicated insufficient evidence to reject the null hypotheses for the interaction effect, the main effect of ST Math participation status, and the main effect of gender.

Implications

ST Math Participation Status

Although over 3,900 schools in 47 states have implemented the ST Math program (ST Math, n.d.b.), the current study found no significant difference between students participating in the ST Math program and students not participating in the program on motivation and engagement. Comparing the results of this study to the findings in the literature was difficult because most of the studies in the literature examined the effects of programs like ST Math on students' academic performance rather than motivation and engagement. Results found in the literature were positive overall regarding the effects of the ST Math program or similar programs on achievement. However, because positive motivation and engagement have been linked to increased student achievement, the results of the current study stood in contrast to some of the research in the literature.

In contrast to this study, Wells and Sheehey (2013) reported that students using instruction embedded in technology had a higher rate of on-task performance than when technology instruction was not used. In a study by Wendt et al. (2014), the students who received instruction using the ST Math program with integrity demonstrated significantly higher mean scores on the California Standards Test compared to those in the same grades that were not provided access to the program. Wendt et al. (2014) determined that a statistical significance existed for mathematics achievement for second-, third-, and fifth-grade students with no significance in achievement for fourth graders. Is suggested that the program provided a platform for understanding mathematics concepts.

Although a couple of researchers noted that programs like ST Math would not increase motivation and engagement, most researchers made claims that programs that embed game-like designs would enhance motivation that translates into higher achievement. On the one hand, Katz et al. (2014) concluded that game-like features, like those in programs like ST Math, did not increase motivation in their student sample. However, on the other hand, Rutherford et al. (2014) conducted a study that implemented the ST Math program because of its game-like design using exercises formulated to engage and motivate students to solve mathematics problems. Even though Rutherford et al. emphasized the connection between the ST Math program's design and its potential for affecting engagement and motivation, their study focused more on achievement than engagement and motivation. They argued that programs such as ST Math help students to solve mathematical problems through spatial-temporal representations, limited mathematical symbols, and technical terminology, which support student motivation and engagement. Similarly, Stephens (2015) stated that students who were more engaged in activities experienced more positive emotion and paid more attention in classrooms. Students who were engaged in the learning tended to behave better in the classroom, usually achieved academically, demonstrated more effort, and experienced more positive emotions (Stephens, 2015).

Several reasons surfaced as to why the results of this study stood in contrast to most of the studies in the literature review. First, consistency in how teachers implemented the ST Math program was a factor in the program's effectiveness in increasing students' motivation and engagement. According to the MIND Research Institute (ST Math, 2016), the students need to use the program 90 minutes per week divided into two 45-minute sessions. Because this research was conducted as a causal-comparative, non-experimental study, I had no control as to whether the teachers implemented the program to fidelity. Ozel et al. (2008) reported that the positive effects or outcomes are mediated by how well the technology was used in the classrooms.

Moreover, Stephens (2015) reported that teachers have an influence on student motivation and engagement based on how self-confident they are about their teaching. Second, another variable beyond my control was the size of the sample. The number of scores from the students was limited based on voluntary participation in the ST Math program itself. Third, the time of the year and how the classroom teachers administered the survey were also factors that I could not control. I did not know how individual teachers presented the survey to the students, nor if the students who took the survey took their time in reflecting while answering the questions of the survey.

Gender

Although no significance was found in the main effect of ST Math participation, there was a significant result for the main effect of gender for the fourth-grade students in the current study on both motivation and engagement. Females scored higher compared to males overall on motivation and engagement whether they participated in the ST Math program as an intervention or not. These results aligned with Wierzbitzki (2014) who found substantial differences in motivational forces between males and females. Researchers have discovered gender differences in prosocial behavior and emotions with females viewed as being more emotional than males (Cook & Cook, 2018), which could positively affect their motivation and engagement in the classroom. However, these results contrast with findings that indicated males outperform females in spatial skills needed for mathematics problem solving that emerges around the age of 9 to 13 and widens throughout adolescence (Cook & Cook, 2018). According to Wierzbitzki (2014), males are more motivated by tangible, measurable results, and females are more motivated by intangible rewards such as acknowledgment for task completion. The type of reward or reinforcement aspect could explain why the females scored higher on the survey because no external reward was given for the completion of the survey.

In the current study, significance was found in the main effect of gender for the fourth graders but not the fifth graders either on motivation or engagement. The fifth-grade students not participating in ST Math had a higher mean score for both males and females; however, the differences between each group were only a few decimal points from each other. One reason for these results could relate to Morin's (2014) findings. Morin argued that both genders at this age (fifth grade and above) begin to focus more on building friendships that could result in motivation and engagement that are more positive. Also, Stephens (2015) noted that positive student-teacher relationships resulted in increased motivation and engagement for both genders. Thus, the desire for developing friendships and the deepening of relationships that the teacher formed with the students were confounding variables that could have affected the results of the current study.

Recommendations

Potential for Practice/Policy

This study examined the influence of ST Math participation and gender on positive motivation and positive engagement of student scores from two elementary schools in Northwest Arkansas, one school participating in ST Math as an intervention for mathematics and the other school not participating in ST Math. Smith (2017) noted that implementing digital curriculum for mathematics instruction provided data that are helpful for administrators and teachers to meet the students' individual needs. A similar study by Ozel et al. (2008) emphasized the importance of having technology integration in the curriculum standards and objectives. Researchers have examined technology integration's influence on achievement in academic areas, but little to no focus has been on positive student motivation and positive student engagement using technology. Stephens (2015) explained how motivation and engagement involved students' interests and enjoyment of school, which could result in increased achievement. The findings from this study could provide similar results for other schools with similar populations and grade levels in other suburban areas where schools are implementing ST Math as an intervention. School districts must make decisions regarding what types of technology devices, as well as programs, should be purchased that would best benefit the needs of the student population that the school serves. Students who are involved in the activities or lessons that are being presented tend to show more motivation and engagement (Campbell & Jane, 2012). One of the limitations of this study was the inability to control how the ST Math program was implemented and to what extent the students were involved in their mathematics activities or lessons. Another aspect to consider would be other types of interventions that were used at both schools and how the students were engaged in the process of their learning.

Many laws and educational reforms have shaped the education system. The No Child Left Behind Act (2002) influenced school districts finding interventions to close the achievement gap. Former President Obama's administration wanted to align all state educational standards in an attempt to close achievement gaps, which resulted in the *Common Core Standards* (Fritzberg, n.d.). With the increase in technology advancement, schools are discovering new and better ways to provide interventions to meet students' needs. Out of the Individuals with Disabilities Act of 2004, the RTI framework was developed to provide research-based interventions through remediation or enrichment to provide a meaningful education to all students ("Education for All," n.d.), although school districts do not all follow the same implementation of RTI (Hoover et al., 2008). RTI would be more beneficial if each state and school district were held to a uniform system. The enforcement or regulation on the implementation of RTI would help monitor the closing of the achievement gap in the education system. The development of a standard system for intervention would be beneficial to align the implementation regimen of RTI. Stronger rigor for instruction could result in more guidelines for RTI implementation.

School districts need to consider the necessity to prepare students for beyond-school skills. Many jobs will involve computer-type skills or the use of technology as part of the employee's responsibility (Costley, 2014). Costley wrote about the importance of integrating technology in classroom instruction to prepare the students for the future. Costley stated that technology had influenced students' learning by causing them to be more engaged through hands-on learning experiences. If school districts do not use technology in the classroom, the students may lack the skills needed to work in many fields or might inhibit their education at higher education institutions.

Future Research Considerations

This research study did not provide sufficient evidence that the use of ST Math had any influence on student motivation or engagement. However, the Mind Research Institute indicated an increase in achievement on standardized tests in California (Wendt et al., 2014). The following recommendations were offered for future research considerations:

1. The timing of the school year in which the survey was administered—at the end of the school year—could have affected the results. Future researchers might consider the timing of a motivation and engagement survey when studying ST Math's effect on these areas.
2. Student motivation and engagement can easily ebb and flow throughout the school year. The present study took a moment in time snapshot of the students' motivation and engagement. A longitudinal study could be implemented to compare the results for the students over the entire school year by administering the survey at the beginning, middle, and end of the school year. A study could also examine trends over multiple years or administer the survey to a more diverse population over multiple years.
3. Researchers could investigate how different ethnic groups respond to technology and whether there is a significant link between early technology use and success in the classroom in later grades.
4. Although this causal-comparative study used pre-existing independent variables—one school was already using the ST Math program—future researchers could use an experimental approach and manipulate the ST Math participation variable by implementing the program into a group of randomly selected students. This approach would help control for certain extraneous variables.

5. Research from the literature review indicated that males and females similarly acquire early concepts through elementary school with boys showing increased skills in mathematics over girls ages 12 and 13 (Hyde & Mertz, 2009; Rosselli et al., 2009). This study focused on fourth- and fifth-grade students, which limited its generalizability. Additional research would be beneficial to determine if the results would be the same if younger grades or older grades were the targets for the study. Even though there were no interactions between gender and the participation of ST Math in this study, the fourth-grade females scored significantly higher compared to the males in motivation and engagement. Future research could administer the same survey to the fourth-grade students when these students were in the fifth-grade and compare results to determine if the findings are related more to gender or the age of the students.
6. Future research could develop a more in-depth comparison between specific technology programs such as ST Math and Dreambox, instead of one group participating in a technology intervention and the other one not.
7. Additional research could focus on whether the skills learned through the ST Math interventions are transferred to general assignments, formative and summative classroom evaluations, and state assessments.
8. Another administrative consideration could be the necessity of developing a technology intervention program rubric before adopting a specific technology program such as ST Math or another similar program.

Summary

I attempted to determine if differences existed by gender between students participating in ST Math as an intervention in mathematics classrooms and students not participating in ST Math on students' positive motivation and engagement for fourth- and fifth-grade students in two Northwest Arkansas schools. In Chapter V, I shared an overview of the findings, a conclusion of the results for each of the four hypotheses, implications for practice, and recommendations for future practice.

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