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Implementing Technology Enhanced Mathematical Instruction in an Algebra I Course to Increase Students' Academic Achievement in Mathematics

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by
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Approval Page

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Statement of Original Work

I declare the following:

I have read the Code of Student Conduct and Academic Responsibility as described in the *Student Handbook* of Nova Southeastern University. This applied dissertation represents my original work, except where I have acknowledged the ideas, words, or material of other authors.

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Carlos Marrero________________________
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Abstract

Implementing Technology Enhanced Mathematical Instruction in an Algebra I Course to Increase Students' Academic Achievement in Mathematics. Carlos Marrero, 2019: Applied Dissertation, Nova Southeastern University, Abraham S. Fischler College of Education. Keywords: mathematics instruction, technology, algebra, secondary school mathematics, mathematics achievement

In July 2015, the National Council of Teachers of Mathematics established its position about the use of technology in teaching and learning mathematics. This important step forward opened a promise for many students and teachers that deserve the excellence of high-quality education in one of the most difficult educational subjects. In the 21st century, mathematics education can be one of the greatest recipients of all technological benefits reached by the most advanced societies of the earth.

The purpose of this applied dissertation was to measure the effects in mathematics academic achievement of implementing technology-enhanced mathematical instruction to a group of seventh graders taking an accelerated course of algebra I. The problem of the study was that a large number of students were not achieving proficiency levels in fundamental algebra benchmarks such as algebra modeling, function modeling and statistics, and number system. The study included one experimental group, who received mathematics instruction using technology-enhanced mathematical instruction (TEMI), and a control group, who did not receive TEMI instruction.

Both groups were assessed at the beginning of the experiment with a pre-test and the end of the study with a post-test. Additionally, a motivation survey about the use of technology during mathematics instruction was given to the experimental group at the end of the study.

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Chapter 1: Introduction

Throughout the history of mathematics education, teachers, curriculum specialists, school authorities, and even politicians have investigated different ways in which students can learn mathematics and succeed in all educational levels. Multiple experiments, ideas, and approaches have tried to fulfill the profound gap between mathematics instruction and students' learning. Consequently, many students are not able to show a strong mathematics knowledge in different types of assessments. For example, in the international student assessment test, U.S students performed in mathematics 20 points below the test average placing The United States behind countries such as Japan, Canada, United Kingdom, and Germany (Programme for International Student Assessment [PISA], 2015). Therefore, continuous efforts have been made by implementing pedagogical methods like classroom discourse (Piccolo, Harbaugh, Carter, Capraro, & Capraro, 2008) and curriculum enrichment and differentiation (Beecher & Sweeny, 2008) to promote students' mathematics achievement.

One of the most recent and effective approaches is the use of technology to teach and learn mathematics. The fast evolution of technology in the last 30 years has contributed to modify educational concepts, teachers' beliefs, and students' perceptions. As a result, mathematics education has become a privileged receptor of these great changes. Per the National Council of Teachers of Mathematics [NCTM] (2015), "Technology must be used in this way in all classrooms to support all students' learning of mathematical concepts and procedures, including those that students eventually employ without the aid of technology" (p.1). Consequently, a real revolution has begun touching all components of the educational process.

Moreover, educational programs have been modified and enhanced with the latest advances. Similarly, student and teachers are now equipped with courses that provide instructional strategies using technology. Likewise, the changes have reached areas like professional development. Common planning sessions, educational workshops, and leadership meetings are now focusing on training teachers with new interactive tools. Thus, 99% of teachers have access to computers and the internet (Mistretta, 2005). In contrast, as suggested by Mistretta (2005) only 39% of these teachers used technology to create instructional materials.

Implementation of technology and its effectiveness in students' learning has been investigated throughout educational research experiments. Even though there is a significant number of studies that support the use of technology as a powerful tool to make students learn there are others that show the opposite or no effects at all.

Statement of the Problem

The problem of this study was that algebra I students were not achieving proficient levels in assessed benchmarks such as algebra modeling, function modeling, statistics and number system in the 2017 end of the course Florida Standards Assessment Test. This test is considered by the Florida Department of Education a required high school graduation test. Moreover, students who fail the test will be invalidated upon graduation. Per Miami-Dade Public Schools website (2017) students in the school targeted performed an average of 33.6 % of correct questions in the algebra I FSA test main benchmarks. These results are strong evidence of students' failure in mathematics learning. At the same time, the data suggested an immediate plan of actions to address this problem. Integration of technology in the algebra I curriculum was the instructional intervention proposed to increase students' achievement levels in critical mathematics benchmarks.

Technology integration in teaching practices has been evaluated in multiple types of research. Hudson and Blackmar (2017) claimed that the use in class of a computer-based program named iPASS did not impact students' achievement in mathematics significantly. However, the number of studies proving technology effectiveness in mathematics teaching and learning is extremely greater. Even those studies that did not find the impact on students' scores they concluded that students acquired a better understanding of the topics after using the computer-based programs. On the other hand, there is a recent study that suggested a different approach to increase students' proficiency in the FSA algebra I test. For instance, Dopico (2017) suggested the use of small intervention groups to address students' deficiencies in Algebra I.

Definition of Terms

The following terms are defined.

Technology-based instruction. The term refers to helping teachers to use technology as a tool for learning (Gorder, 2008).

Algebra I End of the Course Assessment test (EOC). The term refers to the mandatory test that all students in the state of Florida enrolled in Algebra I course must take the Florida Department of Education [FLDOE], (2016).

Technology-pedagogy-content knowledge (TPACK). The term refers to a teaching framework that identifies the tools needed by teachers to integrate technology-pedagogical-content knowledge into their teaching practices (Koehler & Mishra, 2009).

Technology Enhanced Mathematics Instruction (TEMI). This term refers to a series of technological approaches that the teacher implements during the mathematics instruction and includes the use of the dynamic software Desmos, GeoGebra. Also, it includes the interactive graphing Calculator TI Nspire, math practice websites such as Khan Academy, IXL, Nearpod, and the students' interactive online textbook.

GeoGebra Software: A free dynamic mathematics software designed for all educational levels and integrate geometry, algebra, spreadsheets, graphing, statistics, and calculus.

Khan Academy: A free website designed for all ages and providing practice exercises, instructional videos, and personalized learning in a variety of subjects including mathematics.

Purpose of the Study

The purpose of this study was to compare the mathematics achievement of algebra I students using technology-based instruction and students receiving a traditional mathematics instruction. The independent variable was the group of students receiving the technology-enhanced mathematics instruction (TEMI), and the dependent variable was the students' academic achievement combined with their motivation to learn mathematics by using technology. Since the limited literature published to help in-service teachers to integrate technology into specific content knowledge such as algebra, geometry, statistics, and probability, the necessity to conduct a quantitative research study that can validate the assumption about the effectiveness of integrating technology during algebra instruction has been the focus of this investigation.

Chapter 2: Literature Review

In 2016, the National Council of Teachers of Mathematics published its position about the importance of the use of technology in teaching and learning mathematics. Per this statement, technological tools are designed to help students understand important mathematical ideas and represent an effective way for educators to communicate and deliver mathematics (National Council of Teachers of Mathematics [NCTM], 2015). The reason behind the efforts made by educational authorities is the difficulty faced across the nation to increase students' achievement in mathematics. Moreover, American students are performing below grade level compared with students from countries with similar or less economic power. In the latest test report from the Program for International Student Assessment, PISA, U.S scored behind four of the seven most powerful economies that are grouped under the G-7 organization (Programme for International Student Assessment [PISA], 2015). For example, in mathematics, American students performed 20 points below the test average. Additionally, U.S fell behind Japan, Canada, Germany, and the United Kingdom for more than 30 points. This data characterizes strong evidence of failure.

Teachers' Perceptions and Technological Readiness

Implementing technology to motivate students' learning has been applied as a short and long-term solution. Since (Prensky, 2010) coined the phrase "digital natives" to describe the students of the 21century, the mathematics curriculum has been experiencing changes in current teaching methodologies. The application of technology to mathematics instruction has turned into a necessity for teachers to reach out every student of this digital era. Current students learn differently in comparison with the past generations of learners. As a result, many teaching methods are changing at an accelerated pace.

In the same way, teachers are posed to learn what the students want. In his book, Prensky (2010) gave the main characteristics of this fast-changing generation. Students currently seated in the classrooms do not want to be lectured, they want to have a more active role in class and feel that their opinions are important. Most important, this generation wants the freedom to create. Consequently, there is a framework for content delivery known as Technological-Pedagogical-Content Knowledge (TPACK). This teaching philosophy has two important components, students, and teachers. Technology readiness represents a challenge for teachers, administrators, and schools' authorities. Teachers' perceptions and beliefs toward technology have a variety of variables; they can be grouped in some categories such as experienced, pre-service, in-service teachers, gender, and ethnicity. However, this powerful combination that integrates content, pedagogy, and technology is not exempt from issues. These barriers arise throughout the path of the teacher professional transformation. While teachers, administrators, and curriculum developers work intensely to bring these changes to students' lives, critical elements such as a current physical, technological inventory of resources, teachers' willingness to accept new teaching practices, teachers' collaboration, time for individual professional development and common planning attempt directly or indirectly by slowing down the process. Therefore, at the time to put all the new tools in place, administrators, curriculum specialists, and educators face several difficulties.

The factors affecting the delivery of math instruction include teacher's perception and skills readiness toward the new technologies. Kaleli-Yilmaz (2015) emphasized the importance for teachers to have a strong pedagogical content knowledge before implementing technology integration in a math class. Koehler and Mishra (2009) defined the importance of having the technology, pedagogy, and content knowledge (TPACK) foundation to develop a high level of technology application. However, the same article accepted the difficult reality of putting technology and pedagogy working together. For example, for teachers who earned their teaching degree in a time where technology was a distant dream this transformation is a real challenge.

In the same way, Wideline (2016) analyzed the relationship between teachers' attitude and perception about technology and the frequency in which the teachers applied it in their classroom. This study targeted the science, technology, engineering, and mathematics STEAM program. The results of the study encouraged educational authorities to provide more technology training through professional development activities before and during the execution of the program. Likewise, Sen and Ay (2017) found in the investigation lack of professional development courses in middle school mathematics and science teachers. Also, Sparapani and Calahan (2015) suggested that one of the main factors for teachers to use technology was the technology availability in their classrooms. The second and third factors were teachers' training and teachers' interest in technology applied to instruction. Likewise, Sparapani and Calahan found that teachers considered the use of technology only if professional development courses are offered. Equally important, Sparapani and Calahan noted that teachers' perception of technology is shaped by the school administrator's vision. For example, when the school's principal showed a commitment to find resources and training courses, then more teachers were eager to use technology in class. Similarly, Bautista, Cañadas, Brizuela, and Schliemann (2015) suggested the correlation between teachers receiving professional development workshops aimed to increase their technological skills and their willingness to transfer what was learned into their teaching practices. On the contrary, as suggested by Can Aran, Derman, and Yağcı (2016), when teachers have negative opinions about the use of technology is mainly because they have an inefficient ability to use it.

Importance of Professional Development and Technology

Professional development for teachers has been historically the solution to increase all the main components known as TPACK (Koehler & Mishra, 2009). Teachers can learn, share, and promote a collaborative learning culture through their participation in Professional Development (PD) activities. Moreover, as stated by Murray (2014) "It is so crucial that all teachers engage in effective professional learning activities, regardless of their current instructional proficiency and the relative abilities of their students" (p.7). According to DeJarnette (2017), there are some PD designs that can help teachers to deal with the use of technology. One of these designs can achieve better outcomes when the teachers are grouped by content level instead of a mixed team that cannot effectively work with their assigned curriculum and the characteristics of their grade level learners. Teachers need the freedom to select what content will be used to implement the new instructional technologies.

Along with the selection of the content, teachers should also decide what group of students will be part of the new technological approach. The participant teacher decided to practice with its honor class. In summary, after six months of professional collaborative learning in which the math teacher was introduced to two technology tools and common planning sessions, the teacher increased its level of confidence by integrating the dynamic software Geogebra to its teaching practices (DeJarnette, 2017).

At the outset of professional development theory, the focus has been to provide educators with educational tools that help them to grow in their professional field by learning from new pedagogical teaching methods. Content and technology interaction are essential parts to have the students learning in a successful instructional setting. Student academic results depend on this interaction (Chieh Wayne Yu & Okojie, 2016). As noted on Chieh Wayne Yu and Okojie (2016), “sometimes the knowledge of pedagogy upon which technology is based is not properly addressed” (p.61). Professional development workshops cannot be planned under one size fits all philosophy (Koehler & Mishra, 2009). These courses must address specific teachers’ needs due the lack of pedagogical content knowledge necessary to integrate technology (Chieh Wayne Yu & Okojie, 2016).

Introducing technology training can be addressed through PD workshops with short and long terms goals. In some cases, short terms workshops do not help teachers to follow-up with technology application in math instruction (Gningue, 2003). In this study, teachers were enrolled in two groups to receive different professional development courses. One of the training was a long-term course, and the other was a short-term course. The courses included preparation to work with the graphing calculator “TI-83 Plus”, and the second course was about the application of the Geometer Sketchpad in geometry instruction. The investigation concluded that teachers participating in the long-term PD course showed a high level of commitment and motivation in technology application. Moreover, this course changed teachers’ attitudes and beliefs toward the use of technology in math classes.

In contrast, the short-term form of professional development was not effective for the participants (Gningue, 2003). Also, teachers complained about the lack of continuity and follow-up leaving the teachers discouraged to keep on with what they have learned. On the other hand, the long-term course allowed the teachers “To learn, practice, reflect and be tested on the different activities involving the “TI-83 Plus and the Geometer Sketchpad” (p.219). Equally important, the study concluded that most teachers in both groups expressed the lack of support from the schools' administrators (Gningue, 2003). Stated briefly, it is a fact that teachers can change their perception of technology immediately after professional training.

Particularly important for teachers' training is the involvement of the school administrators. These courses that can be held onsite or outside the school; they should be planned and monitored by the leadership team. A physical inventory of technology must be done before creating an action plan to provide teachers with effective and realistic workshops that can satisfy their technical demand. During a study made by (Sorensen, Shepherd, & Range, 2013) a series of surveys were given to faculty and staff to measure the level of technological readiness before planning professional development activities. Principals must be aware that technology implementation in teaching practices also depends on technology assistant personnel. Without well-trained technicians, teaching through technology has a high risk of failure (Sorensen, Shepherd, & Range, 2013).

Moreover, the same study recommended that the effectiveness of the professional development workshops depend on duration, follow-up, students' assessment data, and teachers wishes (Sorensen, Shepherd, & Range, 2013). Also, Sorensen, Shepherd, and Range (2013) noted that the planning stage of setting a professional development activity on technology must be teacher-centered. Likewise, all PD activities must be "content-relevant, job-embedded, and longitudinal" (p.83). These recommendations seem to be valid regarding the audience to how the training is designed. Adult learners as stated by Fogarty and Pete (2007), need to have control of their learning, its immediate utility and anticipate how they will use the learning in their job.

As a part of the efforts to provide teachers with a professional training that allow them to assimilate and apply technology in-class instruction, the University of Alabama developed a master technology teacher professional development plan aimed to train in service and pre-service teachers in two cohorts at middle and high school levels by introducing technology in class (Wright, 2010). The main goal was to expose future and current teachers to new technologies along with the creation of a learning design that can help individual schools to improve academically using technology (Wright, 2010). Also, the program offered teachers with specific solutions for their classroom needs. In a like manner, the project included high school students taking algebra and geometry. These students created a study guide, video tutorials, and worksheets posted online designed to help them pass mandatory exams required for graduation. This type of collaboration increased students' motivation to work in groups by using a preferred technology approach (Wright, 2010).

Similarly, the project was extended to other core classes such as English and science. The next activity was a paperless project in which students cannot use a formal paper to write their class assignment; instead, they will use a social media platform to express themselves such as Twitter, personal blogs, and Wiki. Also, the study found that under these teaching practices students increased their willingness to write and discuss topics about a novel (Wright, 2010). These results were only possible through an ambitious professional development training that was focused on building technology integration through different content areas (Wright, 2010). The experience accumulated during ten years of implementation of this ambitious professional development program for technology application can be summarized as a successful approach to incorporate many teachers from different grade levels into the TPACK teaching framework. Most important, the positive effects in students learning have been one of its main results. The study concluded that professional development programs could overcome typical opposite forces against technology integration such as lack of resources and teachers' readiness. Also, the investigation noted that participants-built self-confidence, strategies, and learned from failures and successes (Wright, 2010).

The technology role in mathematics instruction has become a critical domain for teachers to grow professionally. Professional development has been the platform to carry these efforts; it is also the most effective approach to engage teachers with different levels of technology knowledge, perceptions, and beliefs in a pedagogical transformation. According to Charischak (2000), teachers consistently need ongoing staff development to improve their teaching practices. In the same study, a group of middle school math teachers were part of a professional development initiative that lasted three years. The training program helped teachers to integrate computer software programs into mathematics instruction. Therefore, the program started enhancing the TPACK teaching structure. Moreover, Charischak (2000) noted "teachers liked to be helped in the classroom, be assisted in planning more effective lessons, and be helped with carrying out the lessons, especially when the lesson involves technology" (p.5). Furthermore, at the end of the program teachers enjoyed working in learning communities (Charischak, 2000).

Offering a high-quality professional development plan that increases teachers' digital literacy is fundamental to enrich students' technological skills (Albertsen, Audi, & Mulvany, 2014). Students cannot master technology only by using some electronic devices at home (Albertsen, Audi, & Mulvany, 2014). Teachers have the responsibility to provide these skills through class instruction. Consequently, teachers are encouraged to enhance their instruction by first managing available technology. In a like manner, (Albertsen, Audi, & Mulvany, 2014) found that teachers want to have professional development courses that not only teach them how to use the technology but how to integrate it to their taught curriculum. In other words, Albertsen, Audi, and Mulvany (2014) encouraged administrators to allow time along the school year for teachers “to discuss, reflect, and plan future lessons” (p.10).

Gender, Ethnicity, Age, and Technology

In a like manner, there are other aspects playing different roles about teachers' perception of the use of computers such as gender, ethnicity, and race. Ocak (2005) found “Consistent and significant gender differences in computer confidence and anxiety among mathematics teachers” (p.86). Also, the same study suggested that new generation of mathematics teachers showed preference toward computers than older teachers. Likewise, (Ocak, 2005) statistically found that “White male and female teachers express greater knowledge about computers than nonwhite male and female teachers” (p.86). Another study that supports the differences between gender and race toward the use of technology arrived at similar conclusions. Kim and Chang (2008) found significant gender differences regarding computer use.

Moreover, the same study suggested that Hispanic students use computers to learn by their own better than other races. Equally important, gender differences are present in certain students’ population. For instance, in (Lee & Yuan, 2010) found that female teenagers showed less motivation during the use of virtual manipulatives in mathematics classes. On the other hand, the same study found that boys of the same age group showed more motivation and engagement with the virtual manipulatives (Lee & Yuan, 2010). However, in (Chieh Wayne Yu & Okojie, 2016) gender differences were not significant in selecting technology to support students’ learning.

Additionally, (Chieh Wayne Yu & Okojie, 2016) found age differences toward selecting appropriate technology to address specific topics. Younger teachers considered students' pace of learning as a factor to select an effective technological tool. To the contrary, teachers in the age group of 51-56 were undecided. In a like manner, gender differences are shown in students' perception and attitudes toward virtual manipulatives (Lee & Yuan, 2010). For example, students' motivation, and enjoyment while learning math by using manipulatives were more significant in male than female adolescents (Lee & Yuan, 2010).

Pre-Service Teachers and Technology

Equally important, pre-service teacher education programs play an important role in future mathematics-technology framework success. As suggested by Belbase (2015), "Preservice mathematics teachers have a limited opportunity for a practical pedagogy of mathematics when they are in content and method courses" (p.43). Thus, mathematics instruction will be affected if they are not mentored by expert teachers that help them build their pedagogical skills. This preparation includes the effective use of technology. Even when pre-service teachers are not competent with the technological tools to instruct mathematics concepts a change can experiment if they are exposed to these approaches and are prompted to change possible negative beliefs Belbase (2015).

Moreover, access to technology is another critical factor in teachers' perception. Per Goos and Bennison (2008) stated "Access to computers appears to be a significant problem for many teachers" (p.118). However, in the same study, teachers expressed confidence to teach mathematics using technology. Conclusively, teachers' perspective on technology is affected by pedagogical knowledge, previous experience in using technology, access to hardware, software, and participation in professional development courses to enhance their computer skills (Goos & Bennison, 2008). The teacher preparation in technology must start at the undergraduate level and later must continue with professional development activities (Albertsen et al., 2014). In the same study, (Albertsen et al., 2014) found that the undergraduate curriculum does not provide future teachers with a deep digital literacy background.

Particularly important about technology use is the pre-service teacher beliefs on this topic. Even the deficiencies about technology application in many teachers' educational undergraduate programs, there is a common perception among pre-service teachers of the importance to have a general technology preparation; however, in (Şen, 2012) pre-service teachers agreed that their undergraduate preparation was incomplete in terms of readiness to introduce technology in a subject area. The results of the study are similar to previously mentioned research regarding barriers that pre-service teachers considered critical to have an effective technology integration. These problems are often related to the cost of technology, limited facilities, causing loss of time when not using effectively, and being too complex during the math instruction using technology (Şen, 2012). Indeed, pre-service teachers have evaluated the use of GeoGebra in math education regarding teaching practices (Doruk, Aktumen, & Ayteking, 2013). In a qualitative study, with a sample of 34 pre-service teachers, opinions about the use of GeoGebra unanimously supported this application as a factor to increase students' interest in mathematics (Doruk et al., 2013).

In the same way, pre-service teachers agreed on the effectiveness of GeoGebra in promoting students' confidence in this subject area. However, pre-service teachers found GeoGebra manipulation a very complicated task for unprepared teachers and students (Doruk et al., 2013). Moreover, the pre-service teachers complained about the new 3D version, “It is not suitable for teaching some basic concepts” (p.151). These findings are opposite to previous opinions about the easy use of this software. Coincidentally, this study arrived at similar conclusions as (Şen, 2012) in aspects such as time to prepare students for standardized exams, teachers’ incompetence to use GeoGebra, and lack of technical facilities (Doruk et al., 2013). According to (Doruk et al., 2013), pre-service teacher believed that GeoGebra is better to teach geometry than other math topics. On the other hand, all the teachers reported that they would be using GeoGebra in their future classrooms. However, pre-service teachers requested more professional preparation to manipulate this software in future professional learning activities (Doruk et al., 2013).

The use of virtual manipulatives is associated with teachers’ beliefs and preferences on technology application. Pre-service and in-service teachers have different perceptions about physical and virtual manipulatives. As suggested by (Akkan, 2012), either pre-service and in-service teachers have used more physical manipulatives than virtual; however, in-service teachers expressed a stronger desire to use virtual manipulatives more often than the experienced teachers (Akkan, 2012). In comparison, in the same study, both groups of teachers have positive beliefs about the use of physical and virtual manipulatives in mathematics education (Akkan, 2012). Similarly, both groups of teachers coincided that one possible negative effect of virtual manipulatives is the amount of time required to assess students.

Technological-Pedagogical-Content Knowledge Framework (TPACK)

Based on research, Technological-Pedagogical-Content Knowledge (TPACK) has become the theoretical framework to integrate technology in education (Stoilescu, 2015). The TPACK framework stems from (Shulman, 1986) Pedagogical-Content Knowledge (PCK), and constitutes an adjustment to the new circumstances generated by the evolution of technology in the new century. Despite the advantages of this pedagogical approach, TPACK has some limitations regarding taking in consideration teachers' attitudes and opinions about methods of teaching (Stoilescu, 2015). However, TPACK transforms not only teaching practices but current curriculum designs.

The curriculum has been defined in multiples ways. In (Glatthorn, Boschee, Whitehead, & Boschee, 2016, table 1.1) is mentioned the existence of three different approaches that can be summarized as a planned instructional content that will be delivered to the students using materials and resources. Technology is one of those resources that effectively can transfer the different types of the curriculum such as the hidden, recommended, written, taught, learned, and tested (Glatthorn et al., 2016). The hidden curriculum (Glatthorn et al., 2016) "might be seen as those aspects of the learned curriculum that lie outside the boundaries of the school's intentional efforts" (p.28). The organization of the classroom is controlled by the teacher. This control has different areas such as the selection of the content and the methods of learning (Glatthorn et al., 2016). According to (Abramovich & Brouwer, 2004) the hidden curriculum can be used to connect research and practice in mathematics education.

Moreover, (Abramovich & Brouwer, 2004) suggested that the pre-service teacher's use of technology can "make significant progress in connecting their informal exploration with formal mathematics "(p.8). In a like manner, the hidden curriculum allows universities authorities to incorporate technology into educational programs (Abramovich & Brouwer, 2004). Furthermore, there are experiences such as the one investigated in Brock University in which the mathematics-technology curriculum partnership with Ontario schools was studied to determine its effectiveness at different grade levels (Martinovic et al., 2013). Furthermore, the study focused its attention on how this partnership is transferred to university teachers' programs designed to prepare future teachers in the same technology-mathematics relationship. According to (Martinovic et al., 2013), the mathematics curriculum in Ontario promotes technology integration as a primary factor to increase students' learning and achievements in this subject area. Also, (Martinovic et al., 2013) mentioned the importance of technology in mathematics by citing Ontario schools' curriculum documents that emphasize the necessity to enhance mathematics-technology partnership especially for secondary school students. In contrast, the same curriculum recommends the use of technology as a teacher option but not as a pedagogical requirement. Likewise, (Martinovic et al., 2013) found that technology-mathematics partnership faces important challenges such as the selection of the students' textbooks by the board of education, bureaucracy, and financial limitation.

The same research study evaluated the teacher education program at Brock University. The university curriculum authorities have been implementing technology preparation in their undergraduate courses for a long period. These programs known as MICA I, MICA II, and MICA III have helped pre-service teachers by introducing the schools' mathematics curriculum integrated with technology to their teaching programs (Martinovic et al., 2013). Conclusively, (Martinovic et al., 2013) have praised the results obtained under the implementation of this experience.

Similarly, (Hegedus, Dalton, & Tapper, 2015) suggested the broad range of areas in which technology integration has a strong impact. In this case, study, consisting of two large investigations focused on the algebra curriculum with the application of dynamic, interactive software, wireless network, and a student-centered teaching method, researchers found "significant impact on student learning of core algebra concepts including both procedural and conceptual problems" (p.203). Moreover, the study found no significant difference between student achievement and its socio-economic status. Especially interesting, researchers found that gender is not a significant predictor of students' scores in algebra tests. However, girls performed better than boys (Hegedus et al., 2015).

Technology Integration and Results Using a Dynamic Software

Despite teachers' perception and readiness on the use of technology in class, there are valuable researchers that demonstrate its effectiveness in increasing students' results in mathematics courses. The use of dynamic software to deliver mathematics instruction has been highly effective in all levels of education. Modeling with GeoGebra, free dynamic software has influenced both teachers and students' perceptions of technology positively. As noted in (Hall & Lingefjard, 2017) using GeoGebra teachers can expand students' abilities to model real-life problems more effectively than with the old formal modeling techniques.

Additionally, students can solve more difficult problems and move their reasoning to a higher level of thinking. In the same book, (Hall & Lingefjard, 2017) recommended the use of GeoGebra in teachers' training programs at the university level. Particularly important, teachers' beliefs about the use of technology changed after the implementation of the dynamic software GeoGebra Tatar (2013). This study noticed that students changed their perception of mathematics and increased their learning gains after being using GeoGebra Tatar (2013). These learning achievements include higher education students. The use of GeoGebra was effective in introducing complex calculus concepts such as derivative, limits of functions, tangent lines, slopes, and exponential regressions in college students Budinski and Subramanian (2013).

Moreover, Budinski and Subramanian (2013) found that “The use of GeoGebra supports students in making new conjectures and in tackling experimentation” (p.87). Another area in which GeoGebra can be used is in modeling other disciplines (Marciuc & Miron, 2014). For instance, high school students applied mathematical modeling using GeoGebra in their science classes. This tool helped them to model the curvilinear motion of a point (Marciuc & Miron, 2014). The study found that visual representations of mathematics concepts were achieved after using GeoGebra (Marciuc & Miron, 2014). Indeed, students taking physics in the same high school experienced the use of GeoGebra as a tool to demonstrate centripetal acceleration. Also, it was used to construct geometric objects needed to understand the circular motion and the radius of curvature (Marciuc & Miron, 2014). The list of science topics that can receive great benefits from GeoGebra is extensive: Modeling the system Sun-Planet-Moon, modeling the velocity hodograph, vectors and Euclidean geometry (Marciuc & Miron, 2014). To conclude, (Marciuc & Miron, 2014) stated that “Involving students in the development of these models creates motivating learning situations and creates the premises for generic competence training, with a high degree of transferability, in Mathematics, Science and Technology” (p. 287).

Particularly interesting, the application of GeoGebra has helped students to understand extremely complex mathematics concepts by increasing their deductive reasoning processes allowing them to assimilate many complicated ideas of the mathematics world (De Moura Fonseca & De Oliveira Lino Franchi, 2016). Also, GeoGebra equips the students with different visual representations of the same object. During this process, students will be interacting with a high level of inductive analysis helping them to attain multiple related perspectives of the same concept (De Moura Fonseca & De Oliveira Lino Franchi, 2016). The study conducted by (De Moura Fonseca

& De Oliveira Lino Franchi, 2016), investigated how GeoGebra was effective during teaching convergence of series. The group included 32 students taking Calculus II at a local teaching institute in Minas Gerais, Brazil. The class activities were designed using GeoGebra. The main objective of this experiment was to make possible for students to interact and acquire the three worlds of mathematics defined by Hilbert: formal mathematics, theoretical mathematics, and practical mathematics (De Moura Fonseca & De Oliveira Lino Franchi, 2016). According to the results of the study, (De Moura Fonseca & De Oliveira Lino Franchi, 2016) concluded that after the use of GeoGebra, students grasped the concept of convergence of mathematics series. Likewise, the grade of visualization provided by using this software allowed the students to understand different representations of the same mathematical concept. Lastly, during class participation, students could create conjectures and had the opportunity to verify their validity (De Moura Fonseca & De Oliveira Lino Franchi, 2016).

GeoGebra has been applied to explore and analyze complex functions in mathematics undergraduate courses. For instance, (D'azevedo Breda & Dos Santos Dos Santos, 2016) described through examples, how to use GeoGebra to help students understand the complex function behavior along with a detailed explanation of the steps to be followed by the students to produce three-dimensional graphs. Also, (D'azevedo Breda & Dos Santos Dos Santos, 2016) recommended: "the exploitation and dissemination of these applications are essential so that, this powerful tool can get to where it is most needed—to classrooms" (p.108). To the same conclusion and recommendation arrived (Hewson, 2009) after applying GeoGebra to a statistics class, stating that "GeoGebra is an exciting application that deserves widespread use within the Mathematical world "(p.171). In another study, (Caballero-Gonzalez & Bernal-

Rodriguez, 2011) found beneficial the use of GeoGebra to introduce an important calculus concept, derivatives. Same results were observed, students performed better using the dynamic software than using the traditional method (Caballero-Gonzalez & Bernal-Rodriguez, 2011).

In a like manner, the application of GeoGebra has been effective in primary school mathematics (Korenova, 2017). A group of students, between nine and eleven years of age, were part of a study to verify if the use of the dynamic software GeoGebra can be considered as an effective tool in primary school mathematics. This study was centered on using the same teaching framework known as TPACK; that invite teachers to integrate pedagogy, technology, and content knowledge in their teaching practices. Geometry was the mathematics topic investigated; however, the study increased the teachers' technological literacy that could enable them to expand the use of GeoGebra to other mathematics learning objectives (Korenova, 2017). According to (Korenova, 2017), the study found that the use of GeoGebra is a very effective tool to learn geometry at the primary education level. Secondly, teachers can increase software potential by using interactive boards and ready-made GeoGebra applets. Conclusively, (Korenova, 2017) encouraged teachers to apply GeoGebra to increase students' technological literacy; and suggested that future teacher training activities must include courses that prepare teachers for the use of this software.

GeoGebra is not the only technological tool that is effective in teaching mathematics. In a calculus learning experience using technology Serdina Parrot and Kwan Eu (2014) noticed that calculus students who used the graphing calculator TI-Nspire found easier to understand high difficult concepts. Also, their motivation to learn mathematics improved dramatically. Moreover, the use of the graphing calculator TI-

Nspire helped teachers to incorporate technology as part of their lesson plans Johnston, Riordain, & Walshe (2014). TI-Nspire has had effective reviews from the two classrooms perspectives, students, and teachers. For example, (Lapp & John, 2009) discussed the functionality of the TI-Nspire on undergraduate students by combining the secondary mathematics curriculum with their current math courses. Students received a brief training on how to use this graphing calculator. The level of mathematics connections reached at the end of the implementation of the program revealed that students enjoyed learning abstract algebra using a graphing calculator. Additionally, the study found that an effective technology integration needs support materials to succeed (Lapp & John, 2009). In the same way, students found themselves exploring new mathematical ideas and concepts while using the TI-Nspire graphing calculators (Lapp & John, 2009).

Student achievement is positively affected using computer technology (Shirvani, 2010). In this study, most of the participants were freshman Afro-American and Hispanic students. At the same time, the selection criteria included lower-achieving students taking algebra I. A total of 127 students were divided into two groups: experimental and control. One group of students were exposed to technology integrated into algebra I while the second group did not have computer access. After the conclusion of the experiment, the experimental group showed better results than the students in the control group (Shirvani, 2010). However, when all the students, including low and high-achieving students, were incorporated into both groups, the study found no significant differences between them.

On the contrary, students' positive attitudes toward algebra were higher in the experimental group than in the control group (Shirvani, 2010). Another aspect, student motivation was favorably affected. As a result, students in the experimental group expressed satisfaction by learning mathematics using technology. The study suggested that teachers must know the importance of applying computer-assisted technology to increase academic achievement in algebra I lower-performing students (Shirvani, 2010). Also, it is important to analyze some differences between different technological tools and the grade of the effectiveness of each one. For example, in an important longitudinal study involving algebra I students and teachers, it was found significant differences in students' math achievements between students using a graphing calculator and students under a program known as Connected Classroom Technology CCT (Irving et al., 2016). The CCT facilitated a more dynamic learning experience on students learning algebra I. The connected classroom technology used in this study was the Texas Instrument Navigator that connect teachers' computers with individual student's handheld graphing calculators (Irving et al., 2016). This communication system supports the multiple-choice questions; as a result, teachers can assess students' work almost instantly from their computers. At the same time, teachers can capture students' graphing calculator screens and display them on the smart board to discuss possible mistakes. The CCT experience is a wonderful instrument to create formative assessments such as class discussion, feedback, and group projects (Irving et al., 2016).

Additionally, the positive effect on areas such as algebra topics and students' positive perception of technology is one of the features of the CCT experience (Irving et al., 2016). Therefore, professional development courses were created to train teachers in how to work in a CCT environment as part of the technology integration process. In (Irving et al., 2016) is suggested that "teachers were introduced to the potential of CCT to improve student achievement" (p.136). This study, conclusively found, that students under the CCT experience increased their algebra achievement throughout the three years that this experiment lasted (Irving et al., 2016). Moreover, other aspects such as gender, grade level, ethnicity, and teachers' professional degree were not a significant variable that affected the final results. However, participants had a profound math background knowledge along with a strong technical readiness on using graphing calculators (Irving et al., 2016).

In a like manner, one study confirmed an increase in students' ability to communicate mathematics concepts when they used a bi-modal approach consisting in a notepad and an own created online blog Freeman, Higgins, & Horney (2016). Through this study, researchers found an increase in students' understanding of the subject. Similarly, in Evans and Gracanin (2009) students used wireless and interactive multimedia technology during instructional sessions. The study found a significant increase in students' abilities to solve problems, simulate real experiences, and collaborative learning with other students in the class.

Similarly, positive effects can be measured at the high school level. In Wang, Chung, and Yang (2014) mathematics teachers used a handheld electronic device called "clickers" that allow students to answer questions and teachers can provide immediate feedback. The key-pads were used in a geometry class. The students' answers were recorded anonymously. Also, the study found a high level of engagement in students using "clickers" than in students not using it at all Wang, Chung and Yang (2014). Most important, special education and English language learners' students showed better test scores.

Technology integration has been proven effective to increase learning achievements for exceptional children (Aronin & Floyd, 2013). In this article, authors suggested that pre-school students with learning disabilities increased their confidence and independence after using the iPad technology. Likewise, the use of iPad educational applications allowed students with poor motor skills to participate more actively in classroom activities (Aronin & Floyd, 2013). In a like manner, the use of this technology allowed teachers to introduce important components of the STEAM education program for students at this age (Aronin & Floyd, 2013). Equally important, STEAM components have worked together to generate a positive learning environment for students at the middle school level. For example, a collaboration between a middle school and a university technology program to integrate robotics to some STEAM components such as science and mathematics have improved mathematics learning in a population of sixth-grade students (Ardito, Mosley, & Scollins, 2014). After introducing robotics in a sixth-grade mathematics class for more than one semester, students could apply important mathematics concepts and ideas to the construction of their robots (Ardito et al., 2014). As a result, this experience developed problem-solving skills. The participant teacher noted that most of the students participating in this experience showed a better comprehension of geometry topics like the circumference of the circle (Ardito et al., 2014). The teacher attributed this learning achievement to the integration of robotics into math lessons. Another aspect that was positively impacted was student collaboration. The teacher noted that students increased their interpersonal relations while working in groups constructing the robots.

Moreover, the teachers found a higher level of respect between the students while working in teams (Ardito et al., 2014). The same result was reached after reviewing students' blogs. Students were invited to write their experiences after every class. Most of the students' comments were positive evaluating the class activities along with their relations with the other peers (Ardito et al., 2014). Stated briefly, this type of learning experience combining robotics and mathematics in middle school level was highly satisfactory for teachers and students. As concluded by (Ardito et al., 2014) "This study demonstrates how these type of tools and methods can reshape the classroom environment regarding student collaborative work and problem-solving skills" (p.85).

The spectrum of technology, as an effective tool to learn mathematics, reaches a diverse population of learners. For instance, advance mathematics visual impaired students improved their learning gains under a high-tech assistive technology (DePountis, Pogrund, Griffin-Shirley, & Lan, 2015). In this study, a total of 35 assistive technologies were assessed by the teachers' participants. The main goal of this investigation was to identify the most effective assistive technology to learn advance math in visually impaired students. After a mixed qualitative and quantitative investigation that included 82 participants, it was found that teachers of visually impaired students used assistive technology to teach important advance mathematics topics in areas like algebra I and algebra II. Also, the investigators used a matrix designed for multiple functions such as preparation of lessons, student lesson access, teacher and student-guided practice, independent student practice, and student work submission to gather all the information about the effectiveness of the different technologies.

Moreover, the study compiled a list of the most effective assistive technology devices in teaching advanced math to visually impaired students: a personal computer, electronic refreshable braille notetaker ERBN, and the talking scientific calculator (DePountis et al., 2015). Another conclusion of the study was the teachers' necessity to receive training on the assistive technologies implemented in the study. One more aspect, (DePountis et al., 2015) found some negative factors affecting the use of these technologies such as the lack of support from schools' districts in providing the latest versions of these technological devices due to budgets cuts along with the preparation time required for teachers to reach an acceptable level of technical readiness (DePountis et al., 2015). Similarly, visually impaired students have been successful in learning algebraic expressions using a digital e-text reader called eText player (Bouck, Meyer, Joshi, & Schleppenbach, 2013). This qualitative study targeted three visually impaired students in their mathematics classes using the e-text reader. Participants were trained in the use of this device. At the end of the process, the students, through different surveys showed a high level of understanding by manipulating complex algebraic expressions (Bouck et al., 2013). In the same way, the students noted that the use of this technology allowed them to have a more enjoyable learning experience compared with their classes using large-print books. Last, of all, the study concluded that even that the students did not show a significant difference in academic achievement after being using the eText device, its use contributed to enhancing student's motivation to learn new algebra topics from different perspectives (Bouck et al., 2013).

English language learners (ELL) is another population of students that have received positive benefits from technology integration. In a qualitative study conducted in a title I elementary school for two years aimed to observe three different scenarios: a classroom, an intervention group, and a computer lab, evaluated the use of technology to increase math achievement among ELL students (Ganesh & James A. Middleton, 2006). The class observation verified the pedagogical content, the use of technology, mathematics representations used and student-teacher verbal interaction. The classroom teacher along with the ELL specialist was frequently interviewed about their opinions on the use of technology in their math classes (Ganesh & James A. Middleton, 2006). After a long research process that included hours of observation, interviews, and surveys, the study concluded that mathematics learning outcomes in ELL students increased after the use of technological tools such as classroom computers, and a math software (Ganesh & James A. Middleton, 2006). Also, teachers noticed a higher level of comprehension in certain mathematics topics such as fractions bars, graphs, equations, and geo boards. In a like manner, (Kim & Chang, 2010) examined in a longitudinal study the effect of computer access, and computer use among ELL students to reduce the gap in math achievement compared with English- speakers. Based in the three variables used: computer access, computer use, and computer use to learn mathematics, the study found that one of the variables, computer access, had a positive effect for ELL students.

In the same way, home computer access had a significant positive effect on both groups, ELL, and native English-speakers (Kim & Chang, 2010). Conclusively, (Kim & Chang, 2010) suggested that ELL students with home computer access for educational purposes "played a more influential role in their math performance" (p.302)

Another important contribution to mathematics learning is the use of Khan Academy. Khan's free video platform provides valuable life lessons that can help teachers and students with a variety of mathematics topics. In Light and Pierson (2014) is suggested that "Khan Academy was useful for improving the procedural skills" (p.117). However, the same study concluded that its use for students does not necessarily promote a profound mathematics achievement Light and Pierson (2014).

Similarly, Microsoft graphing tools have impacted the instruction of linear functions positively. For example, in Kissi, Gyabaah, & Boateng (2016) is suggested that "The use of technology in teaching computers and graphical calculator inspire students to acquire an intense understanding of concepts" (p.120). Likewise, the same study strongly recommends its use for high school teachers to increase technological readiness under the TPACK framework. In another qualitative study, (Cargile & Harkness, 2015) found that

Khan Academy was effective under the flipping instruction set. However, (Cargile & Harkness, 2015) encourages schools' administrators to secure teacher training before implementation of this educational tool.

Moreover, the study found that the lack of technology access is one of the main negative factors attempting to the development of the computer-assisted instruction era (Cargile & Harkness, 2015). Last of all, in a more recent study, (Daniel P. Kelly & Rutherford, 2017) analyzed the effects of the use of Khan Academy on mathematics test scores in an experimental group of seventh-grade students versus a control group. The study found no significant difference in math test scores between both groups (Daniel P. Kelly & Rutherford, 2017). Moreover, statistical methods did not find any association between the use of Khan Academy and higher mathematics scores. However, the study only used one data, students' total points and minutes spent practicing in the program.

Also, new researchers are concluding that the use of some computer-based programs does not affect students' scores significantly on mathematics standardized tests. Per Hudson Blackmar (2017) students from fourth and eighth grade were using a mathematics program called iPASS aimed to increase academic achievement. Contrary to what was expected data collected from a norm-referenced test showed no significant differences between students who spent more than 20 hours practicing math using iPASS and those who practiced the same program for a short period. Another computer-aided program aimed to increase mathematical success in grades 3 to 5 failed to have a measurable positive impact on the Florida Standard Assessment (FSA) math scores Lee (2017). The computer-aided program evaluated was Reflex. Moreover, the study found that students that did not use Reflex scored a little higher than those using it Lee (2017).

Summary

This literature review has covered important factors involving the application of technology in mathematics classes. As noticed throughout this review the number of researchers that support the implementation of the latest technological approaches surpasses those with negative or non-significant results. A substantial group of mathematics topics is receiving an extraordinary benefit by integrating technology into math instruction: calculus, algebra, geometry, statistics, and probabilities. Equally important, the positive impact on specific math contents such as functions, algebraic representations, geometrical relations, modeling, and problem-solving skills has contributed to increasing student mathematics achievements in all grade levels drastically. Technology positive effects can be measured across the K-12 educational system, spreading its benefits from pre-school to graduate students around the planet. Student academic improvement has been the focus of this powerful transformation, transporting teachers and students to another level of learning and comprehension. As a result, students from different academic and social-economic backgrounds are equipped with a variety of technological tools to enhance their learning expectations. From special education passing through advance and ELL students, technology represents a big step forward aimed to meet the goals of the 21-century generation. All of these efforts cannot be possible without a strong teacher preparation on technology. Most of the success of this teaching framework depends on how teachers can manage the volume of different technologies in everyday life. Schools authorities know these challenges and are working diligently to provide enough budget to fund training programs and professional development activities to help teachers to move into this fast-changing train. Teaching mathematics effectively is a constant challenge for teachers and educational authorities.

Technology has come to make the difference between the components of the education system. The art of visualizing mathematics can be done through different technological approaches such as dynamic software, tablets, smartphones, computers, graphing calculators, and interactive lessons. Abstract concepts written in a textbook now take shape and colors. However, teachers must be aware of all the elements that play a positive or negative role in developing these changes. Teacher attitude is essential to implement technology in class. Most of the time their perceptions are affected by their lack of knowledge and training on important technological skills. As suggested by Mistretta (2005) "It is therefore important that teacher education programs determine effective ways to prepare teachers to integrate technology into their classrooms" (p.23).

Moreover, teachers can promote a technology-based learning environment when they can integrate technology into their teaching practices. Also, teachers' access to hardware, software, and training programs is another factor that can impact in one way or another the integration of technology in mathematics lessons. Per Goos and Bennison (2008) "A proactive approach to increasing teachers' comfort with and use of technology needs to address issues of access to computers and graphics calculators" (p.127).

In summary, the integration of technology in mathematics teaching is not a secret formula that will fix all the academic issues related with students' achievements, but it is an effective way to increase understanding and motivation to learn this subject. These ingredients can have a measurable positive impact on students' performance. Consequently, the following research questions were created to find real responses to the big dilemma: student mathematics achievement.

Research Questions

To generate answers to the problem of this study the following questions were designed:

1. What is the effect of the use of technology during algebra instruction in students' mathematics achievement?
    a. How does the achievement of students in technology-enhanced mathematical instruction compare to students who are not in technology-enhanced mathematical instruction?
2. How does the use of technology during algebra instruction affect students' motivation toward learning mathematics?

Chapter 3: Methodology

This applied dissertation has a profound intention to evaluate students' academic achievement in mathematics by implementing a curriculum enhanced with technology. The variety of mathematics concepts, definitions, and ultimately abstract procedures that all students are exposed during a regular math course require the teachers to rethink many aspects of their teaching philosophies and best practices. Multiples approaches have been recommended by pedagogical authorities such as the National Council of Teachers of Mathematics (NCTM) to help students to learn this subject more effectively. Moreover, the combination of certain teaching strategies with technology in the class has posted a tremendous alternative for educators to engage students in the learning of mathematics fields such as algebra, trigonometry, calculus, and statistics. Prensky (2010) stated that "today's students will not live in a world where things change relatively slowly" (p.5). On the contrary, students are experiencing constant and rapid transformations almost daily. Many of these events are associated with the use and dependency on advance technologies. Therefore, teachers are called to build a new relationship or partnering with technology. This relation cannot exclude pedagogy, but it encourages teachers to merge both. As noted by Prensky (2010) "technology's role, therefore, is to support the partnering pedagogy" (p.99). This current revolution, technology applied to instruction, goes beyond the effort to engage one type of intelligence and it is translated into total freedom in which all students are given the opportunity to use all the available technology (Prensky, 2010). Although, that the use of technology in class can be affected by economic conditions such as budgeting restrictions, local, state, and federal funding, (Prensky, 2010) recommends exhausting the possibilities given by minimum access.

Since the use of technology in class is in some way, an undefined suggestion in teachers' instructional guides, the purpose of this research is to provide mathematics teachers with evidence that can support a more aggressive implementation of current technological approaches to their mathematics teaching instruction. Even though, that every new idea faces a natural powerful resistance the objective of this chapter is to display all the methodology that will be followed to collect and analyze the data coming from the students' experience learning math with technology. This methodology includes the study site, the participants, the procedures, and the research design.

Study Site

The research study took place in a public middle school located in a Southern state. The school was built in 2008. Throughout its history, the school has served a low-income community making this school a designated title I school. Also, the school has a large English language learner population. According to 2018 data, the school English Language Learner (ELL) population was 10% of the total. Demographically, this is a multiethnic school with an enrollment of 1670 students in the last school year 2017-2018. From this total, 97.4 % is Hispanic, 0.4 % Black, and 0.3% Asian. Among this population, there are 1470 free or reduced lunch students that represent 85.8% of the total.

On the other hand, the instructional staff is composed of 72 certified teachers. According to the school data, the school has 54 highly qualified teachers, 12 teachers have a reading endorsement, five are National Board certified, and 31 have ESOL endorsement. Additionally, 43.06 % or 31 teachers have 15 or more years of experience. Also, 26 teachers have advanced degrees, representing 36.1 % of the total.

Participants

An important primary component of every research design was the type of sampling strategy used. According to (Edmonds & Kennedy, 2017), the appropriate selection of individuals can strength the investigation and its findings. Moreover, as noted by (Edmonds & Kennedy, 2017), “the goal often, but not always, is to eventually generalize the finding to the entire population” (p.19). Among the nonprobability sampling techniques, this study implemented the convenience sampling. According to (Edmonds & Kennedy, 2017), “the investigator selects individuals because they are available and willing to participate” (p.20). The sample population participating in this research study were two groups of 33, and 25 seventh grade students respectively enrolled in two math classes. The researcher taught those classes for the current school year. These students were participating in the middle school acceleration program that allowed them to take high school classes while they are at the middle school level. The students in the sample population will be taking the Algebra I end of the course exam (EOC) by the end of the school year which is a standardized test that it is at the same time a high school graduation requirement. From a total of 58 students, the treatment group (N=25) received the technology-enhanced mathematical instruction (TEMI) for 1 hour and 45 minutes every other day for eight weeks since the school follows a block schedule.

On the other hand, the control group (N=33) received the algebra instruction under a conventional instructional setting for the same period. This sample of students had a mixed composition (32 Female, 23 Male; age range 12-13 years). The demographic composition of the groups is 100 % Hispanic. The school principal and the assistant principals responsible for students’ schedules assigned the students to the treatment and control group. Identification of the students in the treatment and control group will remain undisclosed.

Before conducting the study, the researcher obtained all the necessary approvals from the different educational authorities — for example, the district school board in which the school is located. According to (Creswell, 2015), “permission is often necessary before you can enter a site or collect data” (p.146). Therefore, the researcher followed the authorization guidelines of the school district. Along with the school district requirements, the principal of the school gave a written consent allowing the researcher to implement the study and to provide the necessary support during the investigation. All of these institutional authorizations were requested before any approach to the participants.

Procedures

The literature review supported the use of technology as an important teaching strategy to increase students’ mathematics achievement. Likewise, in many studies, the use of technology changed the students’ perception of this subject in positive ways. Consequently, the main goal of this study was to find scientific responses to the crucial research questions stated previously. Also, at the end of the intervention, the research’s results provided important evidence that will equip educators with valuable facts about the effectiveness of the technology-enhanced mathematical instruction (TEMI).

Research Design. Since the purpose of the study was to find evidence that supports the assumption that the use of technology can increase students’ academic performance in mathematics, a between-subjects approach was implemented. As suggested in (Edmonds & Kennedy, 2017), “the between-subject approach, also known as a multiple group approach, allows a researcher to compare the effects of two or more groups" (p.35). This approach has a pre-and posttest control group design as seen in table 1.

Table 1

Research Design

Assignment	Group	Pretest	Treatment	Posttest
R	1(n=25)	District Algebra I Topic Test	TEMI Intervention	District Algebra I Topic Test
R	2(n=33)	District Algebra I Topic Test	-	District Algebra I Topic Test

Independent and dependent variables. According to (Edmonds & Kennedy, 2017), the independent variable (IV) is the one being manipulated. In this study, the group of students that received the proposed TEMI intervention represents the independent variable. Additionally, this treatment was implemented to measure its impact on the dependent variable (DV), students' academic achievement and motivation to learn mathematics by using technology. Also, this study was aimed to find the causation among the variables. Therefore, this study avoided threats to internal validity that can have a negative impact on the cause and effect relationship between the variables involved in the investigation. One of those possible threats is instrumentation. The researcher used only two measuring instruments, the district algebra I topic test and the online motivation survey.

Data Collection: District algebra I topic test. According to (Creswell, 2015), right after the process of identification of the variables, the researcher should start looking to find a tool to measure such variables. This process is called operational definition. This instrument was the district algebra I topic test that was designed by the district department of mathematics and science to measure students' mathematics achievement in a variety of benchmarks. This test provided important information about the students' current level of proficiency in the subject compared with the rest of the students in the school and the district taking the same algebra course. The District algebra I topic test was administered to both the control and the treatment group during the first week of the study. Likewise, the same test was administered at the end of the study to both groups as a posttest. This measuring instrument helped to answer research question 1: What is the effect of the use of technology during algebra instruction in students' mathematics achievement? Moreover, its second part: How does the achievement of students in technology-enhanced mathematical instruction compare to students who are not in technology-enhanced mathematical instruction?

Motivation survey. The researcher implemented another data collection instrument to answer the second research question: How does the use of technology during algebra instruction affect students' motivation toward learning mathematics? It was an online survey that was completed by the treatment group. The instrument contained ten statements asking the students to express their level of motivation of learning mathematics with technology. Every statement had a 5-point Likert-type rating scale, where students responded from *strongly agree to disagree strongly.* According to (Creswell, 2015), this is an interval ratio/ scale with equal distances between responses.

Reliability and validity. According to (Creswell, 2015), "a goal of good research is to have measures or observations that are reliable" (p.158). Since in this study, the researcher administered a pre and posttest instrument to measure the dependent variable, students' mathematics achievement, it was important to determine if this assessment is reliable or not. The district algebra I topic test was given twice, at the beginning and the end of the experiment. As suggested by (Creswell, 2015), the test and retest reliability consist in administering the test in two different times to the same group of participants.

The district algebra I topic test has been used by the school district for many years as an assessment tool to evaluate levels of proficiency among the students. This test and its projected application met the reliability components described by (Creswell, 2015, table 5.3). In the same way, the online motivation survey was presented to the school principal for revision and approval.

Data analysis. One of the most important processes of the research study is the analysis of the data collected through the district algebra I topic test and the motivational survey. This phase of the experiment as suggested by (Creswell, 2015), must show standards and ethical practices. Particularly, in this study, the data of the pre and posttest was analyzed at the beginning and the end of the intervention. Measures of central tendency such as mean, median, and mode were calculated to describe the data.

Additionally, measures of spread were found such as standard deviation and range. The researcher used Excel as the statistical program to calculate all the descriptive and inferential tests. Moreover, after the data was recorded the researcher inspected the data to find missing or mistakes entering the information. In a like manner, the researcher conducted an inferential analysis by testing the hypotheses. As recommended by (Edmonds & Kennedy, 2017), this experimental design included the effect-size calculations. Finally, to answer the second research question, an online survey was administered, and the responses of the participants related to their motivation about learning mathematics using technology were analyzed to determine percentages of participants choosing each response.

Summary

This chapter described the entire process of how the study was implemented and how the data was collected and analyzed by the researcher. This process is critical for the accuracy and the quality of the experiment. The researcher followed all the recommended steps suggested by (Creswell, 2015) while conducting a quantitative experimental design. This chapter explained the different instruments used to collect the data and ultimately answered the research questions of the experiment. Similarly, the research design was described in detail to clarify all the components of the investigation such as the variables involved and how the nature of the treatment and control group was preserved throughout the investigation.

Chapter 4: Results

This chapter describes the results of the study derived from the collection of the data and the statistical analysis. The purpose of this investigation was to measure the effects of technology-enhanced mathematics instruction in students learning algebra compared with students learning the same subject but not receiving the technology intervention. The dependent variable in this study was the students' academic achievement in mathematics and their motivation to learn algebra after being exposed to a variety of activities involving technology such as the use of graphing calculators, the dynamic software GeoGebra, the graphing computer application Desmos among many others virtual experiences. The mathematics achievement of the students in the treatment group was compared with the scores of the students who did not receive the Technology Enhanced Mathematical Instruction (TEMI). A pre- and post-test was used to determine the academic status of the students in both groups at the beginning and the end of the experiment. This test included important algebra benchmarks aligned with the Florida mathematics standards for algebra I. Additionally; a survey was used at the end of the study to analyze students' perception, motivation, and level of satisfaction about the use of technology in the algebra class.

The problem that triggered this study was that the students were not achieving a proficient level in the Florida standard test for algebra I. The quantitative research study was conducted to measure the effects of instructing algebra using TEMI on students' academic achievement and motivation. The study targeted two research questions:

1. What is the effect of the use of technology during algebra instruction in students' mathematics achievement?

a. How does the achievement of students in technology-enhanced mathematical instruction compare to students who are not in technology-enhanced mathematical instruction?

2. How does the use of technology during algebra instruction affect students' motivation toward learning mathematics?

Quantitative Data

Quantitative data collection started in October by implementing the district topic test as a pretest assessment measuring students' achievement in a variety of algebra benchmarks. These algebra standards included the ones where students showed levels of deficiency in the state standardized test back in 2017. Function modeling and algebra modeling standards were assessed in the control and the treatment group. The treatment group received the technology-enhanced mathematical instruction for eight weeks during an hour and forty-five minutes each period of class every other day. The same district test was used as a posttest at the end of the study. Both groups took the assessment for a second time, and percentages of correct answers were analyzed using descriptive statistics.

Results for Research Question 1

Results from the pretest and posttest were analyzed using statistical tools such as measures of central tendency like mean and median. Additionally, a t-test difference between two means was conducted with the treatment and control group. The mean score of the treatment group (N=25) in the pretest was extremely low. Students overall performance was 30.48%. At the same time, the control group (N=33) scored slightly higher but still a very low average of 33%.

Table 2 shows the descriptive statistics measurements that provide a complete picture of the distribution of the scores in the experimental group at the beginning and the end of the study. For example, the treatment group scores showed that the data in both assessments is particularly symmetrical since the standard deviation, which is a measurement of spread, is very small. Since the standard deviation represents the average distance of every data value and the mean, most of the scores are clustered around the mean. Additionally, median and mean in both tests coincided. This is another evidence of a normally distributed data.

Table 2

Pretest and Posttest Descriptive Statistics Treatment Group

Pre-test Score. Treatment Group		*Post-Test*	
Mean	30%	Mean	52%
Standard Error	0.022899199	Standard Error	0.021641935
Median	30%	Median	52%
Mode	26%	Mode	50%
Standard Deviation	0.114495997	Standard Deviation	0.108209673
Sample Variance	0.013109333	Sample Variance	0.011709333
Kurtosis	1.457365105	Kurtosis	0.163832543
Skewness	0.706146891	Skewness	0.445458742
Range	0.54	Range	0.44
Minimum	8%	Minimum	34%
Maximum	62%	Maximum	78%
Sum	7.62	Sum	13.12
Count	25	Count	25

In the same way, the data from the posttest showed the skewness closes to zero as another evidence of normality. Moreover, minimum and maximum values determined the range that is ten points higher in the pretest than in the posttest. Likewise, regarding distribution, the data is displayed with similar symmetrical structures in the pre-and posttest. Equally important, the comparison of the means of the pretest and posttest showed a difference of 22%. Students' overall percentage of correct answers in the posttest increased significantly compared with the average scores in the pretest.

Similarly, the control group data were analyzed using the same descriptive statistics tools. Table 3 showed the measurements of the center such as mean, median, and mode along with measurements of symmetry like kurtosis and skewness.

Table 3

Pretest and Posttest Descriptive Statistics Control Group

Pre-Test Score Control group		*Post-Test*	
Mean	34%	Mean	43%
Standard Error	0.021922	Standard Error	0.027137
Median	32%	Median	42%
Mode	26%	Mode	48%
Standard Deviation	0.125933	Standard Deviation	0.155892
Sample Variance	0.015859	Sample Variance	0.024302
Kurtosis	-0.80962	Kurtosis	0.666959
Skewness	0.31035	Skewness	-0.18044
Range	0.46	Range	0.74
Minimum	12%	Minimum	4%
Maximum	58%	Maximum	78%
Sum	11.16	Sum	14.22
Count	33	Count	33

The control group improved significantly between the pre-and posttest regarding percent of questions correctly answered. The mean increased nine percent. Even that, it is still less than the difference of the means of the treatment group. Equally important, the measure of skewness in the post-test is -0.18044 skewing the data to the left. This is also supported by the increase in the range of the posttest compared with the range of the pretest. A minimum value score of 4% pulled the data to the left and increased the distance between the highest and the lowest scores. When comparing this spread measurement between the pre-and posttest is noted that the treatment group range is a significant ten points lower. Another visual representation that can be used to evaluate the symmetry of the data is by using a box and whisker plot. Figure 1 and figure 2 showed a box and whisker plot for both groups using the pretest scores.

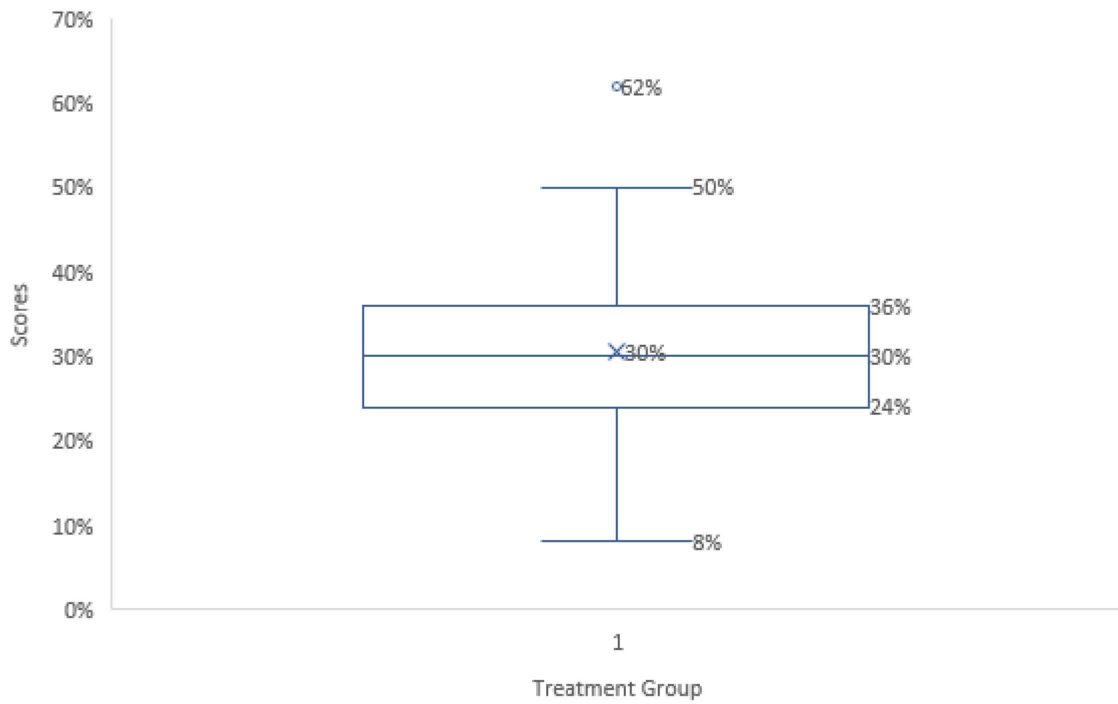

Figure 1. Box and whisker plot showing the data distribution from the pretest for the treatment group.

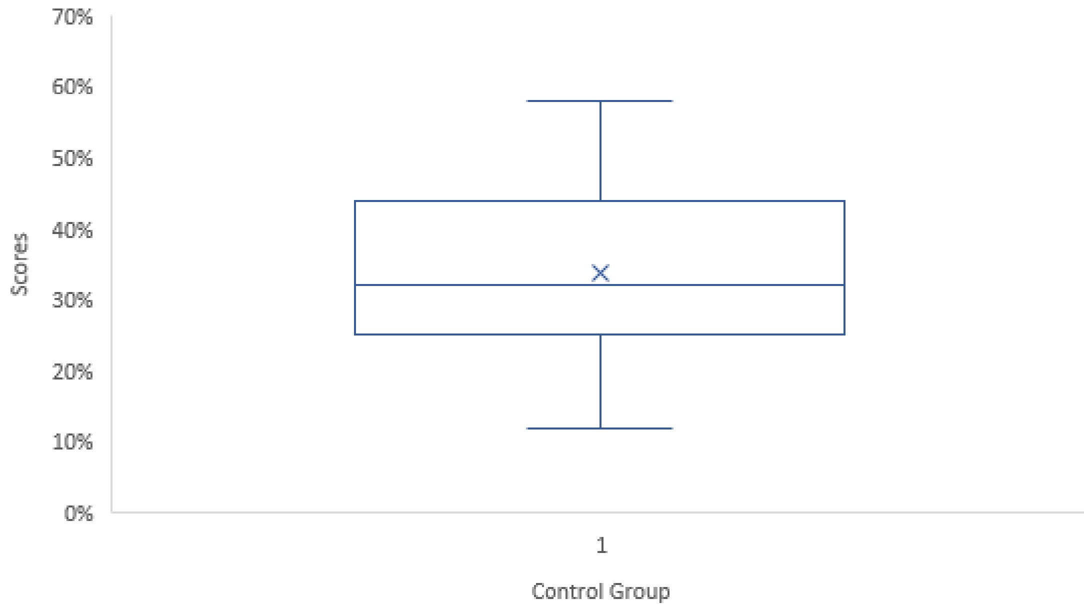

Figure 2. Box and whisker plot showing the data distribution from the pretest for the control group.

Also, a *t*-test analysis was conducted to compare the pre-and post-test scores for the treatment and control groups. According to table 4 and table 5, both groups showed higher means when comparing with the pretest scores. However, the treatment group showed that every student tested scored higher than its respective pretest score. On the other hand, analyzing individual scores in the control group displayed that not all students improved their average of correct questions between the two tests. In a like manner, the two-tail value of the treatment group is less than $\alpha=0.05$. Therefore, there is a significant difference between the means of the pre-and post-test.

In the same way, the p-value in the control group was also less than $\alpha=0.05$ but greater than the p-value in the treatment group. Moreover, the mean value of the treatment group increased more than twice of the mean value of the control group. Another substantial difference in the posttest between both groups was that the minimum individual score in the treatment group was 30 points higher than the minimum individual score in the control group.

Table 4

Paired Two Sample t-Test for Means. Treatment Group

Measurements	*Pre-test Scores*	*Post-Test Scores*
Mean	0.3048	0.5248
Variance	0.013109333	0.011709333
Observations	25	25
Pearson Correlation	0.350509753	
Hypothesized Mean Difference	0	
df	24	
t Stat	-8.660254038	
P(T<=t) one-tail	3.76946E-09	
t Critical one-tail	1.71088208	
P(T<=t) two-tail	7.53892E-09	
t Critical two-tail	2.063898562	

Table 5

Paired Two Sample t-Test for Means. Control Group

Measurements	*Pre-Test Scores*	*Post- Test Scores*
Mean	34%	43%
Variance	0.015859091	0.024302273
Observations	33	33
Pearson Correlation	0.540979135	
Hypothesized Mean Difference	0	
df	32	
t Stat	-3.872564623	
P(T<=t) one-tail	0.000250162	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.000500323	
t Critical two-tail	2.036933343	

The final statistical analysis conducted was the Cohen’s *d* effect size. This measurement analyzes both data using the difference between the means of the posttest results from the treatment and control groups divided by the pooled standard deviation. It is usually performed when the standard deviation from the two datasets are similar. The Cohen's *d* effect size *d*=0.6818 laid in the range between medium and large effect size. Therefore, this is another strong evidence that something happened with the dependent variable of this study, the students' academic achievement in mathematics. Consequently, it was concluded that teaching algebra using technology-enhanced mathematical instruction had a practical significance.

Results for Research Question 2

How does the use of technology during algebra instruction affect students' motivation toward learning mathematics?

To answer the research question 2, students in the treatment group responded at the end of the study to an anonymous online survey created by the researcher. This survey was used to assess students' perception of learning mathematics through lessons that included technology activities (see Appendix)

The first question of the survey about the use of the free online graphing calculator app Desmos was responded positively by 80% of the students. A total of 20 out of 25 students were agreed or strongly agreed about feeling good learning algebra while using this app. The critical second statement of the survey was, "It is more beneficial for you to learn mathematics by using technology." The results recorded showed that 22 out of 25 students or almost 90% of the population was strongly agreed or agreed with the statement. On the contrary, the third statement of the survey, "Students usually prefer math lessons using the textbook only," 56 % of the participants strongly disagreed or disagreed with the statement. The statement about motivation, "Now, I feel more motivated to go to my algebra I class because the teacher uses technology to help us understand the topic than before when the teacher did not provide us with that experience" obtained a 76% of positive responses from the participants. In general, the satisfaction and motivation levels among the students in the treatment group about their learning experience using TEMI approaches were significantly high.

Moreover, in every statement asking students about their perception of the use of technology in mathematics, students showed a positive attitude toward the TEMI experience. The numbers represented most of the responders. Conclusively, 84% of the participants expressed their desire to continue the learning of algebra by using technology in class.

Summary

The purpose of this chapter was to show the results of the study. This process included the scores from the pre-and posttest in the experimental and the control groups. Additionally, the results of the online survey centered in the evaluation of the levels of motivation and satisfaction among the students in the treatment group were analyzed. All participants were 7^{th}-grade students enrolled in an acceleration program that allowed them to take high school courses such as algebra I, physical science, biology, and geometry during their middle school years. The targeted population was taking the Algebra I course. The purpose of this applied dissertation was to compare the mathematics academic achievement between students receiving their math instruction using technology and students receiving the same math content without using any of these technological approaches. A district topic assessment was administered at the beginning of the study to the students in the treatment and control group. Both groups showed failing levels of proficiency in the pretest. The study continued with the implementation in the experimental group of the TEMI activities for two months.

Immediately after, the same district test was administered to the treatment and control groups. Statistical analysis was performed through a *t*-test along with descriptive statistics tools such as measurements of central tendency and spread. The mean average of correct answers increased drastically in both groups. However, the difference of the means scores between the pre-and posttest in the treatment group was significantly higher than the same difference in the control group. The treatment group average difference was 22% versus 9% in the control group. Moreover, other factors such as minimum and maximum scores were higher in the treatment group than in its counterpart the control group. Lastly, the Cohen's *d* effect size of $d=0.6818$ showed a medium to large effect size indicating practical significance.

Finally, an online survey was given to the treatment group designed to explore students' levels of motivation and satisfaction about their experience learning mathematics using TEMI. Answers to ten questions in the survey revealed that most of the students liked the use of technology while learning mathematics. Also, students expressed their desire to continue learning this subject using the technological approach. Likewise, 76% of the students felt more motivated to learn during the application of this experience.

Chapter 5: Discussion

Overview of the Dissertation

The problem that triggered this study was that a large number of Algebra I students were not achieving proficient levels in assessed benchmarks such as algebra modeling, function modeling, statistics, and number system in the 2017 Florida Standard Assessment Test. Since this test is also a high school graduation requirement the necessity to design a teaching approach to address this problem was unpostponable. Therefore, the purpose of the study was to compare the mathematics achievement of algebra I students using technology-enhanced mathematical instruction (TEMI) and students receiving traditional instruction. The independent variable was the group of students receiving the technology-enhanced mathematical instruction (TEMI), and the dependable variable was the students' academic achievement combined with their motivation to learn mathematics by using technology.

The framework of this dissertation was based on research studies previously conducted that validated the use of technology as an effective teaching practice to increase students' achievement in mathematics along with an increase in students' motivation to learn this subject. Additionally, this study was built using the teaching framework Technological-Pedagogical-Content Knowledge (TPACK) as explained in Koehler & Mishra (2009). Moreover, this study took the recommendation made by the National Council of Teachers of Mathematics (NCTM) in 2015 in which as a position statement recognized that the use of technology is one of the ways mathematics can be taught and learned [NCTM] (2015). In this context, there are many studies that had proven the high level of effectiveness in students' understanding and achievement in mathematics learning through the implementation of the latest technological tools such as graphing calculators like TI-Nspire, online free applications software like Desmos, GeoGebra, and interactive learning websites like Khan Academy.

The number of participants in the study was 58 7^{th} grade students separated into two groups. The control group (N=33), and the treatment group (N=25). These students were enrolled in an acceleration program that allows them to take high school credits classes along with their middle school curriculum. The treatment group received the technology-enhanced mathematical instruction (TEMI) for eight weeks for an hour and forty-five minutes every other day since this middle school followed the block schedule. On the other hand, the control group did not receive the mathematics instruction using TEMI. Both groups took the district topic test as a pretest at the beginning of the study and as a posttest at the end of the experiment. Data was collected, and the mean scores from the pre-and posttest were analyzed.

Additionally, an anonymous online survey was used for the treatment group at the end of the study as a measure of students' levels of satisfaction and motivation toward the use of technology in their algebra class. The quantitative design was used to respond to the two research questions of this study:

1. What is the effect of the use of technology during algebra instruction in students' mathematics achievement?
    b. How does the achievement of students in technology-enhanced mathematical instruction compare to students who are not in technology-enhanced mathematical instruction?
2. How does the use of technology during algebra instruction affect students' motivation toward learning mathematics?

Elaboration and Interpretation of the Results

The design of this study included a pretest at the beginning of the treatment. This assessment tool was also implemented at the end of the experiment. The district topic test was used to make an inventory of the students' proficiency levels in state mathematics benchmarks associated with function and algebra modeling. A total of 13 algebra I standards were present in the test. Results from the pretest showed students in the treatment group performing at an insufficient level in all 13 state standards. Similar results were found in the control group.

Consequently, the researcher planned the lessons used during the time in which the treatment group was exposed to technology-enhanced mathematical instruction (TEMI). These learning activities involved the creation of students' online accounts for Khan Academy. These accounts allowed the students to have homework time that included watching video tutorials of important concepts and procedures related to the state standards evaluated in the pre-test along with practice sessions. In a like manner, the control group practiced the same concepts and procedures but using their hardcopy textbook. Additionally, activities that were aimed to teach students the use of the online graphing calculator Desmos were planned and executed with the treatment group. The instructional activities included time to explore the graphing features and the ways to model important concepts and procedures such as functions, domain, range, and function transformations. Also, interactive presentations using the smart board were implemented to have the students practice with the virtual version of the graphing calculator TI-Nspire. Likewise, the researcher planned interactive lessons using presentations through the learning website Nearpod. Moreover, a set of activities using an alternative graphing software were planned to use the dynamic, interactive algebra version of GeoGebra.

Finally, the students in the treatment group had interactive lessons using their online textbook.

Effect of TEMI activities on the students' academic achievement. Even though, the number of research studies granting almost unanimously a total confidence on the use of technology to increase academic achievement in mathematics, there are other factors such as teachers' technological preparation, budgeting limitation, and teachers' perception that contribute to reduce the positive effects of these teaching practices in the teaching of mathematics among all educational levels. According to Stoilescu, 2015, there is still discussion topics among researchers the effectiveness of the TPACK teaching framework as a pedagogical tool to integrate technology and different instructional subjects at a large scale. Consequently, the answer to the first research question was critical to arriving at conclusions: What is the effect of the use of technology during algebra instruction in students' mathematics achievement? Also, its complemental question: How do students in technology-enhanced mathematical instruction compare to students that are not receiving the same technology-enhanced mathematical instruction?

Both groups of students took the district topic test before the TEMI-based treatment started. This test was designed to evaluate important state standards related to algebra and function modeling. The same assessment was used as a posttest at the end of the experiment to evaluate possible positive, negative or non-effect on students' academic achievement in mathematics along with students' perception about technology after the conclusion of the treatment. Statistical tools were used to analyze important descriptors of the data collected such as mean, median, mode, standard deviation, minimum, maximum, and range. These measurements helped the researcher to understand the distribution of the data. Also, important elements such as the difference between the mean scores of both groups at the beginning and the end of the study helped to establish certain unequivocal results. For example, the outcomes presented in Chapter 4 showed that both groups increased their average of correct questions by the end of the study.

In the same way, a paired-sample *t*-test was conducted to complete the quantitative process of collecting and examining the data. Most important, the data analysis concluded that the treatment group improved significantly better than the control group regarding the mean difference between the pre-and the posttest. The treatment group went up 22 points in an average of correct answers compared with 9 points increase in the control group. Likewise, important descriptors of the data such as the minimum and maximum values showed that the highest score of the test corresponded to the treatment group. On the contrary, the minimum scorer corresponded to the control group. In summary, the use of TEMI-based instruction in the algebra class had a positive impact on the dependent variable of the study, the students' academic achievement in mathematics.

The effect of TEMI-based instruction on students' motivation toward learning mathematics. One of the challenges in mathematics teaching is to provide teachers with teaching strategies and frameworks that can motivate students to learn complex topics. For example, as mentioned in (Kostaris, Sergis, Sampson, Giannakos, & Pelliccione, 2017), teaching methods such as flipped classrooms are contributing to increasing students' motivation and learning. In a like manner, as reported in (Taljaard, 2016), the influences of the implementation of technology in education include student engagement and learning outcomes. Moreover, according to Prensky (2010), what is important in the learning cycle is the student as an individual instead of test scores, content, and curriculum. Likewise, Prensky (2010) encouraged teachers to put more emphasis on knowing the students' interests and passions at the time of designing the lessons to be taught. To address the second research question related to levels of motivation and satisfaction about the use of TEMI- based instruction an online survey was taken by the treatment group at the end of the study. This survey gave solid positive responses about every students' experience using technology during the treatment period. The levels of positive satisfaction and high learning motivation toward the use of technology while learning algebra topics were shared among all students. In particular, 96% of the students surveyed rejected the statement about feeling bored when learning algebra using technology. In summary, the positive effects of the use of technology in students' motivation have been supported by numerous quantitative and qualitative studies on all educational levels including the present investigation.

Recommendations for Educational Practice

Since this study showed a medium to a large practical significance after performing the Cohen's *d* size effect, it is recommendable to all educational stakeholders the implementation of technology as an effective teaching practice to increase students' academic achievement in mathematics learning. Therefore, and after analyzing the extensive literature about this topic, it is suggested to increase teachers' preparation as a critical component before and during the application of this teaching framework. Schools authorities, boards, administration, and educational leaders should plan a more sophisticated training plan to address the different training levels of current and future educators in the use of the latest technology applied to mathematics. Professional development workshops that can be given to teachers and that at the same time promote all components of the teaching framework TPACK is one of this main study recommendations.

Moreover, teachers and school administrators should be aware of the importance of the use of technology as a factor to increase motivation to learn in all students. As a part of the school improvement plan, the administration team should encourage teachers to investigate more about the latest research studies on this topic. Teachers need to know that they are not alone in their daily struggle to get the students sufficiently engaged in the learning process. They must know that students of this century love to learn with computer' application, tablets, a smartphone with interactive features, graphing calculators, and dynamic software. Educators must realize that technology is an ongoing fast-lengthy process that is impacting the way learning is developing, and mathematics education is one of its recipients.

Limitations

There are limitations for this study. The first limitation is related to the sample size. Only 58 students out of 580 that were taking the acceleration program participated in the investigation. If this study could be extended to all students taking algebra I in this school, then the statistical implication of the results will be stronger and more significant at the time to elaborate definitive conclusions. The second limitation is that this study included only a Hispanic population. Therefore, analysis of the effects of technology on mathematics learning in other ethnic groups could not be performed. The third limitation is about the time allocated for the study. Eight weeks was the time assigned to the entire investigation. A more extended period of treatment will provide more information about the dependent variable in both groups of students. Lastly, the participants were honor students taking algebra. An important population of gifted students did not participate. However, the academic background of all participants included students who scored levels 2 to 5 in the last Florida mathematics assessment test giving a diverse academic spectrum to the sample population.

Recommendations for Future Research

Results from this study confirmed that the use of a variety of technological approaches in mathematics learning positively impact students' academic achievement and increase students' motivation and learning satisfaction in a math classroom. Future research should take the limitations of this study as a starting point to extend this investigation to all students at all levels of the educational system. For example, elementary students, middle school students taking regular math, and secondary students at the high school level. Additionally, future researchers should enrich this study by incorporating qualitative missing elements such as teachers' perception on technology, new teachers, experienced teachers, and administration opinions and beliefs about the effectiveness of this teaching framework.

Conclusions

Despite the number of research studies that support the use of technology in mathematics to increase students' academic levels on this subject, these teaching practices are not the only magic formula to solve all the problems in mathematics education. Exclusively to make possible the integration of technology to the rest of the teaching components in the TPACK teaching framework requires many efforts from all educational stakeholders. Technology cannot be fully implemented without proper financial funding. In the same way, teachers' training and mastering of the fast-changing technology field takes time from the lives of the educators regularly facing the pacing of the subject to meet the curriculum before the standardized tests take place. However, teachers can commit time to learn about the effectiveness of these practices as a pedagogical source to reach the desired academic level for their students. This study is an example of how these teaching practices can be effective. The investigation included 58 7th grade students taking algebra I classes. The treatment group was instructed using technologies such as graphing calculators, online applications, an interactive learning website, and a free dynamic software along with the students' online algebra interactive book.

On the other hand, the control group did not receive such a treatment. The practical effect was measured using a district test that students in both groups took at the beginning and the end of the experiment. Lastly, the treatment group participated in an anonymous online survey designed to know students' perception and opinions about the use of technology in their math lessons. Also, the survey provided the levels of students' satisfaction after the use of technology in class.

This research concluded that when an appropriate technology is integrated into mathematics teaching, then students can increase their academic achievement and motivation while learning mathematics. Consequently, math teachers must be trained in the use of technology in math classes in order to promote students' motivation toward mathematics. As a result, students will be more engaged, and levels of understanding and academic performance will increase significantly. It is well known in schools, districts, educational policy makers the effectiveness of the use of technology in math courses. In the last ten years many transformations have occurred, but still, the application process is taking too much time given external factors such as funding and internal factors like teachers' and administrators' perceptions and viewpoints on this topic. Experiences like this study should be shared with all math teachers as a suggestion or alternative for some complex mathematics concepts that are traditionally difficult to attain. Diversifying the different teaching styles and strategies teachers can explore an infinite world of possibilities and start changing the negative perception of mathematics among students.

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Appendix

Frequency Responses of the Treatment Group on the Perception of the Use of Technology to Learn Mathematics

Frequency Responses of the Treatment Group on the Perception of the Use of Technology to Learn Mathematics.

Survey Item	Strongly agree	Agree	Neither agree nor disagree	Disagree/ Strongly disagree
1. By using Desmos graphing calculator, do you feel better with algebra?	5	15	5	0
2. It is more beneficial for you to learn mathematics by using technology	11	11	1	1
3.Students usually prefer math lessons using the textbook only.	0	5	6	14
4.Students are not interested in learning how to use a graphing calculator.	1	4	8	12
5. Students get easily bored when using the computers while learning algebra.	1	1	7	16
6. I prefer to have interactive learning experiences during learning algebra than to be seated doing a lot of questions from my book.	18	7	0	0
7. In general,	6	13	4	2

technology has changed my perception about learning algebra.				
8. Now, I feel more motivated to go to my algebra I class because the teacher uses technology to help us understand the topic than before when the teacher did not provide us with that experience.	8	11	4	2
9. I would like to continue the rest of the year learning algebra using technology.	14	7	4	0
10. Overall, I am very satisfied with the way my instructor is using technology to help me understand difficult topics.	14	10	1	0