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Interactive Technology and Engaging Learners in the Mathematics Classroom

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Abstract

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MS, University of Texas at Dallas, 1994

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Dissertation Submitted in Partial fulfillment

of the Requirements for the Degree of

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Abstract

The Program for International Assessment tested students in mathematics from 41 countries and found that students in the United States ranked in the lowest percentile. This struggle with math among youth in the United States prompted this quasi-experimental quantitative study about using interactive technology to engage and motivate 9th grade students in an Algebra classroom. The theoretical basis of this study was a constructivist perspective, using the Piagetian concept of action as an intellect builder. A convenience sample of 76 students was divided into 4 groups: Group 1, the control group, used no technology and consisted of 21 students; Group 2 used the TI Nspires calculators and consisted of 17 students; Group 3 used the TI Nspire calculators with the TI Navigator and consisted of 20 students; and Group 4 used the TI Nspire calculators, the TI Navigator, and the clickers. The participants were given 45 instructional classes that covered a 9-week period. All groups took the Motivated Strategy for Learning Questionnaire (MSLQ) and the State of Texas Assessment of Academic Readiness test (STAAR) before and after the treatment of interactive technologies. A paired *t* test and a factorial repeated ANOVA were conducted, revealing no significant effect for the MSLQ based on the use of technology. However, the use of technology with the STAAR did show a significant difference in test scores for 2 treatment groups: Group 3, which used the calculator and the TI navigator; and Group 4, which used the calculator, the TI navigator, and the clickers. These results support the use of additional technology that is needed in the mathematics classroom to support the use of the calculators.

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Chapter 1: Introduction to the Study

Introduction

This study was based on mathematical underachievement in American schools that has spanned over a 20 year period. In a report by Steen (2003), the United States was called a "nation at risk" because it was producing underachieving students in the areas of science and mathematics (p.79). "In dramatic language, the National Commission on Excellence in Education warned of a 'rising tide of mediocrity' that, had it been 'imposed by a foreign power,' might well have been interpreted as an act of war'' (Steen, 2003, p.79). Hossain and Robinson (2011) stated that, "science and technology had been powerful engines of prosperity in the United States since World War II but, currently science, technology and mathematics education as well as the capability of the American workforce are in decline" (p.1).

First, the individual states responded to the challenge of improving the achievement in mathematics by establishing the following standards: (a) almost all states established content standards in mathematics, (b) most states increased the required mathematics and science classes from 2 to 4 as a graduation standard, and (c) advanced classes in mathematics and science increased enrollment across racial and ethnic groups (Steen, 2003, p.79).

Next, the Federal government responded to the challenge of improving the educational system by creating the No Child Left Behind (NCLB). The NCLB was enacted as a federal mandate across Grade levels K through 12 that required annual testing and annual improvement of students in Grades 8^{th} through 11^{th}. Various sanctions, ranging from the reduction of federal funding to school closure, would be placed on any school that was not in compliance with NCLB (Steen, 2003, p. 81). With all of the new regulations, Rouse and Kemple (2009) made the following statement based on a report from the NAEP:

> Although the math and reading achievement scores of both 4th and 8th grade American students have improved over the past 17 years according to the nations' "report card," the National Assessment of Educational Progress (NAEP), the math and reading scores of 12th graders have been stagnant or even falling over roughly the same period. (p.3)

Aud and Hannes (2011) in their article for the National Center for Education Statistics confirmed that the current condition of the educational system had improved by a few points on the national level but was still below standards on the international level (p.6).

> In 2009, the average National Assessment of Educational Progress[a] (NAEP) mathematics scale score for students at grade eight[b] was higher in 2009 than in 2007 for all racial/ethnic groups except American Indians/Alaska Natives. Black and Hispanic 8th grade students scored lower than their White counter parts in 2009, by 32 and 26 points, respectively; neither of these gaps was measurably

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[a] The National Assessment of Educational Progress (NAEP) is a congressionally mandated project of the National Center for Education Statistics within the Institute of Education Sciences of the U.S. Department of Education which assesses the American's students' knowledge in various subject areas. The report is called the Nation's Report Card.

[b] Grade 8 will be the reference group during the analysis of prior data because this data is closer to the age of my sample group and control group.

different from the corresponding gaps in 2007 and 1990 (Aud & Hannes, 2011, p. 6).

The National average score for 17-year-olds in mathematics in 2004 showed no statistical improvement from the scores either in 1973 or in 1999 (National Center for Education Statistics, 2005, p. 8). So the NAEP showed gains in the single digit in prior years for 8 grade students or 13 year olds, but no statistical difference for 17 year olds and no gains that would close the assessment gap between the white students and the minority students.

On the international level, reported by the Programme for International Student Assessment (PISA)[c], the students in the United States average mathematics literacy score, in 2009, were lower than the average score of 34 OECD[d] countries (Aud & Hannes, 2011, p.8). The TIMSS (Trends in the International Mathematics and Science Study) stated that the mean math and science scores of United States 15-year-olds were lower than some of the less developed countries (Hossain & Robinson, 2011, p. 2). Internationally, the United States is trailing 19 countries that produced more scientists and engineers and less developed countries are now outperforming the United States in areas of math and science achievement (Hossain & Robinson, 2011, p. 2).

The search for solutions to low performance on math assessment has brought multiple ideas and theories into action but no real solution to low math scores has been

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[c]The Programme for International Student Assessment (PISA) was created by the OECD countries to regularly monitor the quality, equity and efficiency of school systems in about 70 countries.

[d] Organization for Economic Co-operation and Development (OECD) – a league of countries that banded together in 1961to promote policies that would improve the economic and social well-being of people around the world (www.oecd.org)

identified. One set of authors stated that the lack of progress for improving mathematical achievement has to do with the strategies used but in fact the problem is in the underestimation of the problem and the underestimation of the efforts needed to correct the problem (Steen, 2003, p. 81). Another group of researchers related to improving mathematical assessment focuses on changing the students' beliefs regarding themselves and their performance and using motivation to actively engage the students in the learning environment (Lehman, Kauffman, White, Horn, & Bruning, 2001, p. 1).

If mathematical learning is viewed from a social constructivist's perspective then the theory is that learning should be collaborative, constructive, interactive, and within the context of the mathematical concepts (Klopfer, Yoon, & Rivas, 2004, p. 347). Serafina and Cicchelli (2003) quoted the Cognition and Technology Group at Vanderbilt (CTGV) when they wrote, "that the constructivist theories supporting cognitive process in the curriculum emphasize students engaging in learning activities in which they are actively involved in the construction of their own knowledge through exploration, reasoning and the application of problem solving strategies" (p. 80). In Piaget and Inhelder's (1973), memory and intelligence research, they concluded that methods associated with "action" built a better memory of prior mathematical knowledge. Interactive technology provides an "active" environment where students can explore in-depth mathematical problem situations needed for higher order thinking skills on math assessment.

Researchers have proven that interactively-stimulated learners, using any media to accomplish that interactive stimuli, are the learners with the most conceptual knowledge

(Fulford, 2001, p. 31). All of the research that presented has indicated that mathematical learning should not be generated from a teacher-centered pedagogy, which is characterized by the learning that is enforced today. The strategies for 21st century teaching and learning must contain some type of interactive technology or interactive stimulus that will engage the intelligence of the techno savvy 21st century learner. President Obama made the following statement in a speech he gave on education:

> I'm calling on the nation's governors and state education chiefs to develop standards and assessments that don't simply measure whether students can fill in a bubble on a test, but whether they possess 21st century skills like problem-solving and critical thinking and entrepreneurship and creativity (Hossain & Robinson, 2011, p.5).

Problem Statement

Low performance on mathematical assessments is a national epidemic. Grimes and Warschauer (2008) stated the following about the educational system in the U. S:

> The reading and mathematics test scores at the high school level are no higher now than they were 30 years ago (National Assessment of Educational Progress, 2005), inquiry-based learning is declining in schools due to pressures of standardized testing, and the U.S. workforce remains woefully under-prepared (p. 305).

According to Bybee & Stage, (2005) "our teens are among the worse at math in the world" (p.69). Our teens represent the future of this country in mathematics. If they are the worse in the world in math then this country will be the worse in the world in mathematical research in the future.

In the literature review, many examples of the effectiveness of technology in classroom settings were given, but none of the authors extended their results to the effects of technology on national assessments. In my literature search, I did not find the following statistical relationships: (a) a relationship between technology and motivation, (b) a relationship between motivation and test scores, and (c) a relationship between technology and test scores. The most important aspect of the literature review was that there is not enough research on interactive technology. This study increased the knowledge base for the use of interactive technology and hopefully it will send a message to policymakers that the quality of the educational system needs more universal standards that incorporate interactive technology.

In this study, I compared the effect of using interactive technology in a classroom setting with the traditional method of a teacher-centered pedagogy. I also compared test results before and after the use of interactive technology with a control group test results. In this study, I made inferences that predicted the outcome of using interactive technology as a motivator to improve test scores on a local, state, and national level.

Purpose of the Study

This study had two purposes. The primary purpose was to have a technological effect and the secondary purpose was a social effect. The purpose of this quasi-experimental, quantitative study was to investigate whether specific types of interactive technology, TI Nspire calculators and clickers, had the following effects:

- motivated the students to participate actively in the classroom activities
- motivated the students to perform at a higher level on an assessment test

Klopfer, Yoon, and Rivas, (2004) found that the use of technology encouraged the students to voluntarily participate in the learning environment regardless of their gender, race, or socio-economic status (p. 354). Masgoret and Gardner (2003) stated the following about motivated individuals:

> The motivated individual expends effort, is persistent and attentive to the task at hand, has goals, desires, and aspirations, enjoys the activity, experiences reinforcement from success and disappointment from failure, makes attributions concerning success and/ or failure, is aroused, and makes use of strategies to aid in achieving goals. (p. 128)

The resolution of the problems in this study could be a major step forward toward improving motivation of students and changing the pedagogy in mathematics education.

Research Questions

Six research questions guided this study:

1. Does interactive technology, the TI Nspire calculators, provide the stimulus or action needed to increase students' motivation and interest in the mathematical classroom?
2. Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or action needed to increase students' motivation and interest in the mathematical classroom?

3. Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' motivation and interest in the mathematical classroom?
4. Does interactive technology, the TI Nspire calculators, provide the stimulus or "action" needed to improve students' test scores?
5. Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or "action" needed to improve students' test scores?
6. Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' test scores?

The study participants completed two pre assessments and two post assessments. In the pre assessments, I recorded: (a) the students' existing levels of motivation, and (b) the students' level of knowledge and skill in mathematics. In the two post assessments, I recorded: (a) a post motivational assessment to measure any improvement due to the use of technology, and (b) a post mathematical assessment to measure any improvement due to the use of technology.

Hypotheses

I created six hypotheses and six null hypotheses associated with these research questions. They were:

$H_1$1: There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators.

$H_0 1$: There is no significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators.

$H_1 2$: There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator.

$H_0 2$: There is no significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator.

$H_1 3$: There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator and the clicker.

$H_0 3$: There is no significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator and the clicker.

$H_1 4$: There is a significant increase in students' test scores when using the TI Nspire calculators.

$H_0 4$: There is no significant increase in students' test scores when using the TI Nspire calculators.

$H_1 5$: There is a significant increase in students' test scores when using the TI Nspire calculators with the TI navigator.

$H_0 5$: There is no significant increase in students' test scores when using the TI Nspire calculators with the TI navigator.

$H_1 6$: There is a significant increase in students' test scores when using the TI Nspire calculators with the TI navigator and the clicker technology.

$H_0 6$: There is no significant increase in students' test scores when using the TI Nspire calculators with the TI navigator and the clicker technology.

Hypothesis testing

I conducted hypothesis testing, using factorial repeated ANOVA with the STAAR assessment and Paired sample t-test with the MSLQ, to reject or accept the null hypothesis.

Dependent variables

The dependent variables were the test scores and the numbers generated from the survey tools.

Independent variables

The independent variables consisted of the interactive technology – TI Nspire Calculator used independently, then the TI Nspire Calculators with the navigator and then the E-Instruction clickers was added to the previous technologies.

Theoretical Framework

For the theoretical basis of this research study, I took a constructivist perspective by focusing on the theories of Jean Piaget, the theories of Seymour Papert, and various authors of the National Council of Teachers of Mathematics (NCTM). Jean Piaget's theory of memory and intelligence, Piaget's analysis of the effects of an "affective component" on intellectual development, and the link between disequilibrium and motivation in children will provide the evidence of how memory is ignited and sustained. Seymour Papert, a colleague of Piaget and a supporter of "Piagetian learning," used his knowledge of mathematics with computers to help children focus on their own thinking processes. According to Papert (1980), when a child thinks about his or her thinking processes the child become an epistemologist, an experience not even shared by most adults (p. 19).

Piaget's Memory theory

Memory is the reactions associated with recognition (in the presence of the object) and recall (in the absence of the object; Piaget & Inhelder, 1973, p. 4). There are two issues related to the memory or the conservation of information: (a) learning (the acquisition of the information needed), and (b) the retention or conservation of that information (Gruber & Voneche, 1995, p.790). The link between learning and retention is related to or contingent on the mental assimilation of a schemata (Piaget, 1995, p. 791). Piaget described two types of memory related to assimilation schemata: (a) memory related to perceptual recognition where objects are used to provoke the sensorimotor schema, and (b) memory related to events that are not visible but are perceived as a form of a picture memory (Piaget 1977 as cited in Gruber & Voneche, 1995, p.791).

The memory related to events that are no longer visible is called "evocation" memory and is considered a higher order memory recognition that is actually needed for inferences, logical organization of memory, and mental reconstruction of the past (Gruber & Voneche, 1995, p.791). Evocation memory is the memory that was accessed during the interaction with technology in my research study. Both types of memory uses schemata as intellectual structures to organize and classify events as they are perceived within the nervous system (Wadsworth, 1996, p. 14).

Piaget's Intelligence theory

The acquisition of knowledge or intelligence according to Piaget (1970) is "derived from actions, not in the sense of simple associative responses, but in the much deeper sense of the assimilation of reality into the necessary and general coordination of actions" (pp. 28-29). Piaget separated knowledge into 3 types: (a) physical knowledge – known as the discovery stage, (b) logical mathematical knowledge – known as the invention stage, and (c) social knowledge – known as the social interactive stage (Wadsworth, 1996, p.23). Physical knowledge is acquired when a child uses his or her senses while interacting or manipulating an object (Wadsworth, 1996, p.23). Logical-mathematical knowledge is acquired during the mental or physical manipulations of objectives while the child is either constructing or inventing knowledge (Wadsworth, 1996, p.23). Social knowledge is acquired during the social interaction between the child and his or her peers or teacher (Wadsworth, 1996, p.24). Each of the three types of knowledge depends on actions, whether the action is a physical manipulation of objects or events or a mental manipulation (thinking) of objects or events (Wadsworth, 1996, p.32).

While experiencing the three levels of knowledge, the child approaches three levels of understanding (Ginsburg & Opper, 1969, p. 222). The first level of understanding is called the motoric level. The motoric level describes the child's direct interaction or correct manipulation of objects (Ginsburg & Opper, 1969, p. 222). The second level of understanding is called the intuitive level. The intuitive level describes the child using an abbreviated or internal type of interaction on objects (Ginsburg &

Opper, 1969, p. 222). The third or final level of understanding is called the verbal level. The verbal level describes the child performing purely at an abstract level by verbally articulating concepts derived from mental operations (Ginsburg & Opper, 1969, p. 222). The second and third levels of understanding are high levels of knowing concepts and can only be achieved after the motoric level has been accomplished (Ginsburg & Opper, 1969, p. 223). Piaget confirms this by making the following statement on intelligence that relates to the levels of understanding;

> Intelligence, at all levels, is an assimilation of the datum into structures of transformations, from the structures of elementary actions to the higher operational structures, and that these structurations consist in an organization of reality, whether in act or thought, and not in simple making a copy of it. (Piaget, 1970, p. 29)

The link between memory and intelligence is that they are both stimulated with some form of action and not just by perception using simple abstractions and generalizations (Piaget, 1970, p. 34). Memories are more retainable if the child constructs the knowledge related to learning (Piaget, 1970, p. 36). Memory is not just the function of some basic mental recall mechanism but memory is a function of intelligence where the past is reconstructed from the general schemata of intelligence (Piaget & Inhelder, 1973, p. 378).

Piaget’s Affective component theory

Although the three types of knowledge are related to the cognitive development of the child, Piaget’s intellectual development theory can be profoundly impacted by an affective component. The affective component includes the feelings, the interest, the desires, the tendencies, the values, and the emotions of the child (Wadsworth, 1996, p.30).

> The Affective component plays an important role in the development of the intelligence of the child. It is obvious that affective factors are involved even in the most abstract forms of intelligence. For a student to solve an algebra problem or a mathematician to discover a theorem there must be intrinsic interest, extrinsic interest, or a need at the beginning. While working states of pleasure, disappointment, eagerness as well as feelings of fatigue, effort, boredom, etc. come into play. At the end of the work, feelings of success or failure may occur; and finally the student may experience aesthetic feelings stemming from the coherence of his solution. (Wadsworth, 1996, p.31)

The assimilation of experiences that is used to produce affective schema is also used to build cognitive structures. The results of producing affective schema and cognitive structures are the acquisition of knowledge. Affect is the gatekeeper to knowledge because it is responsible for the activation of intellectual activity and the selection of which objects or events are acted on (Wadsworth, 1996, p. 32). Teachers that allow students to be both physically and mentally active understand the role of intrinsic motivation in intellectual development (Murry, 1979, p. 178). Students that are both physically and mentally active was motivated to complete the given task.

Piaget's Motivation Theory

There are two perspectives for the activation of motivation; (a) the empiricist perspective and (b) the constructivist perspective (Wadsworth, 1996, p. 150). The empiricist perspective for the activation of motivation in children is by reinforcement, an external approach, while the constructivist and Piaget's perspective for the activation of motivation in children is an internal approach. This internal application of motivation is caused by "a state of cognitive conflict" or disequilibration in the child's reality (Wadsworth, 1996, p. 19). Disequilibrium presents an imbalance in the child's reality that forces the child to internally resolve these issues. This force is called motivation. Piaget compared this force to the forces that enable us to biologically adapt to our environment (Wadsworth, 1996, p. 150). So the development of the mind or the acquisition of intelligence is also a process of adaptation where the mental imbalances presented in the learning environment are forced to reach a level of equilibration and accommodation.

Piaget speaks of an intrinsic type of motivation, but this study used an extrinsic type of motivation, to intrinsically motivate the students. This extrinsic type of motivation was provided by the use of various computerized devices known as interactive technology or manipulatives. Interactive technology provided intrinsic motivation for the students because the interactive technology provided the three characteristics that were related to intrinsic motivation. The three characteristics are autonomy – giving the students control over their actions, competence – the students' ability to complete a task on their own, and relatedness – the secured relationships that are developed from students working with each other in a group (Jones, Uribe-Flórez, & Wilkins, 2011, p. 217). Jones et al. (2011) stated that, "one of the most common and intuitive beliefs about motivation is that students are more likely to be motivated to choose and persist at an activity if they enjoy the activity and are interested in it"(p. 216). Jones et al (2011) also stated that, "intrinsic motivation results in high-quality of learning and creativity" (p.216).

Seymour Papert

Seymour Papert, a mathematician who was influenced by Piaget's theories of intelligence and cognitive development, used his constructivist views to connect Piagetian theories with technology. In my study, I used technology as *computer-aided instructions* which meant that the students used the computer as a teaching aid. Seymour Papert used computerized devices that could be programed by students. Papert states the following about the two processes,

> One might say that the *computer is being used to program the child* in one process and *the child programs the computer* in another process. Both processes requires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building. (Papert, 1980, p.5)

Seymour Papert used a computerized, cybernetic animal called the Turtle. The Turtle is a thinking and programming tool that would allow children to explore their own thinking process. This idea was taken from his experiences with Piaget and Piaget's theory of the child as an active builder of their own intellectual structures (Papert, 1980, p. 19) Piaget stated that the learner must perform some type of action to build knowledge and Papert stated that the best learning takes place when the learner takes charge. Paperts LOGO project was an example of the learning programming and debugging a computerized cybernetic animal. Papert made the following conclusion about using computers in a mathematical environment, "significant change in patterns of intellectual development will come about through cultural changes and the most likely bearer of potentially relevant cultural change in the near future is the increasingly pervasive computer presence" (Papert, 1980, p. 216).

Technology and Mathematical Understanding

The National Council of Teachers of Mathematics has focused an entire volume on the interaction of technology in the mathematical curriculum. Knuth and Hartmann (2011) used the calculator and geometric software to engage students in a "conceptual conversation" about mathematics (p.151). The term conceptual conversation, according to Knuth and Hartmann, (2011) meant "a conversation that has a diminished emphasis on technique and procedures and an increased emphasis on relationships, images, and explanations" (p. 151). Peressina and Knuth (2011) stated that, "many of the technological devices (e.g., graphing calculators, computers) and software packages can also be used to facilitate students' learning of basic skills and algorithmic procedures, data collection and analysis, and conceptual knowledge in mathematics" (p. 151).

Peressini and Knuth (2011) named five ways that technology is currently being used as a pedagogical tool in the mathematics classrooms (pp. 278-280). Two of those ways relate directly to my research study: (a) technology can be used as a motivational tool to encourage and engage students in learning mathematics and (b) technology can be used to help students better understand mathematical algorithms, procedures, concepts, and problem-solving situations (Peressini & Knuth, 2011, p.277). When technology is used in problem-solving situations, the technology has the capability of acting as a cognitive tool by supporting students' exploration and engagement with mathematics.

In conclusion, McGraw and Grant (2011), stated from their use of technology in the classroom that, "technology is an important tool for maximizing the opportunities for learning in the mathematics classroom because it offers unparalleled opportunities for investigating and understanding of mathematical concepts" (p. 303).

Theoretical Framework Summary

Piaget confirmed that action is the key to accessing the intelligence of children. Not any action, but action that forces children to build physical and mental models during the construction or invention of knowledge. Piaget also defined the underlying "motivation" related to the building of memory and intelligence as a disequilibration in the reality of the child. This disequilibration in the mind of the child causes confusion in the child's reality, which motivates the child to seek a solution that would place him or her back in a state of equilibration and accommodation. In Piagetian and related constructivist theory, children are motivated to restructure their knowledge when they encounter or experience conflict with their predictions or reality (Wadsworth, 1996, p. 150). Seymour Papert and various authors of the NCTM stated and verified the importance of technology as an intellectual building tool in the mathematical classroom.

In this study, I used the TI Nspire calculator with the TI navigator to monitor the students' calculator screens. I used the e-instruction clickers to assess and immediately report the students' knowledge after the lesson. Both of these interactive tools were manipulated by the students during the exploration of various solutions and mathematical concepts. The students physically manipulated, or performed, some form of action that built a mental assimilation of a schemata. Further exploration, or manipulation, lead the students to restructure their knowledge to permanently imprint their memory with mathematical information.

Piaget stated that, "the 'traditional school' imposes work on the student while the 'new school' appeals to real activity, to spontaneous work, based upon personal needs and interest" (Piaget, 1970, pp. 151-152). In conclusion, if the goals of education are the acquisition of knowledge then the goals of instruction must be rooting in the principles of exploration or discovery (Wadsworth, 1996, p. 149).

Definitions

Affective component: Part of the motivational section of the MSLQ that is related to test anxiety. Some authors have described this as:

> Test anxiety is thought to have two components: a worry, or cognitive component, and an emotionality component. The worry component refers to students' negative thoughts that disrupt performance while the emotionality component refers to affective and physiological arousal aspects of anxiety. (Pintrich, Smith, Garcia, & McKeachie, 1991, p.15)

At-risk students: "Students who are at risk for academic failure for a variety of reason, ranging from low socioeconomic status and learning disabilities to substance abuse and gang-related activities" (Lehman, Kauffman, White, Horn, & Bruning, 2001, p. 1).

Computer algebra systems (CAS): Computer programs that perform the following algebraic task: (a) advanced graphical representation, (b) numerical calculation, and (c) symbolic manipulations
(Nunes-Harwitt, 2004, p. 157).

Control of learning beliefs: Students' feelings that their efforts to learn would result in positive outcomes. "If the students feel that they can control their academic performance, then they are more likely to put forth the needed effort that would achieve the desired changes" (Pintrich et al., 1991, p. 12).

Expectancy component: This is the set of questions in the motivational section of the MSLQ that measures the student's perception of their potential feeling of success in a particular course (Pintrich et al., 1991, p. 53).

Extrinsic goal orientation: "Extrinsic goal orientation complements intrinsic goal orientation, and concerns the degree to which the student perceives herself or himself to be participating in a task for reason such as grades, rewards, performance, evaluation by others, and competition" (Pintrich et al., 1991, p. 10).

Goal orientation: According to Pintrich et al. (1991), "goal orientation refers to the student's perception of the reasons why the student is engaging in a learning task" (p. 53).

Interactive technology: Technology that provides two-way communication. An input from the user is request to obtain an output response. In this study the students interacted with the TI Nspire calculators and the electronic clickers.

Intrinsic goal orientation: “Intrinsic goal orientation is defined with the degree to which the student perceives herself or himself to be participating in a task for reasons such as challenge, curiosity, or mastery” (Pintrich et al. 1991, p. 9).

Manipulatives: Any concrete material that students can touch or manipulate (e. g., boxes, calculators, chalkboard) and it also appeals to the sense and represent mathematical ideas, concepts, or relationships (Jones, Uribe-Florez, & Wilkins, 2011, pp, 218-219).

Motivated strategies learning questionnaire (MSLQ): “MSLQ is a self-reporting instrument that was designed to assess college students’ motivational orientations and their use of different learning strategies for a college course” (Pintrich et al., 1991, p. 3). In this study the MSLQ was given to high school students in an Algebra 1 class designed for students repeating Algebra 1. This questionnaire consisted of two sections, a motivation section and a learning strategies section. Only the motivational section was given to the participants in this study. “The motivation section consisted of 31 items that assess students’ goals and value beliefs for a course, their beliefs about their skill to succeed in a course, and their anxiety about tests in a course” (Pintrich et al., 1991, p. 3).

State of Texas assessment of academic readiness (STAAR): STAAR is a new state test that was started with 9^{th} graders for the 2011/2012 school year and middle school grades 6 thru 8. This test will continue for 10^{th} graders next year until it is totally phased in by the school year 2014/2015. The TAKS test is being phased out and the STAAR took its place. The STAAR in this study, focused on the curriculum that was being covered in the student's present grade. The STAAR is also called EOC for "End of Course" exam. The STAAR consisted of 54 multiple choice questions in 5 reporting categories. Each category contained student expectations that were categorized as readiness standards and supporting standards.

Self-efficacy for learning and performance: "Self-efficacy for learning and performance is an expectancy component of the MSLQ that defines a student's self-appraisal of his or her ability to master a task" (Pintrich et al., 1991, p. 13).

Student expectations (SE): Student expectations or SEs are related to the TEKS, the Texas Essential Knowledge and Skills. The student expectations define what a student is expected to know after the lesson has been taught.

Task value component: "The task value components are items on the MSLQ that defines the student's level of interest of performing a task" (Pintrich et al., 1991, p. 11).

Technologically rich environment: The employment of several computerized tool used to enhance cognition.

Texas assessment of knowledge and skills (TAKS): The TAKS is a state test that is given each year during the spring semester. This test is used by the state to make schools and teachers accountable for students learning. It is also used by the federal government to determine the school and district's "No Child Left Behind" rating.

Texas essential knowledge and skills (TEKS): The TEKS are the state of Texas standards for what should be taught for each subject and at each grade level.

Value component: "The value component of the MSLQ measure the students' intrinsic, extrinsic, and task related goals for classroom participation" (Pintrich et al., 1991).

Assumptions

The major assumption that I made was that the students' low test scores were caused by low or no interaction in the classroom. I also assumed that students' unresponsive behaviors were caused by a traditional curriculum. This curriculum does not meet the mental demands of the 21st century student (Stumbo, Circe, and Lusi, 2005, p. 4). Students today have many high tech devices like cell phones with digital cameras, digital videos, and texting ability. They play 3D and virtual reality video games, communicate via Face Book and My Space, and download music and music videos. They also upload videos to YouTube. The list of their technological devices and their capabilities is endless. These *high tech* students view the *no tech* or *low tech* classroom as boring, and they refuse to participate. The results of this lack of excitement in the classroom are low test scores.

Another assumption that I made was that the participants were biologically and psychologically developed. According to Piaget (1973), the acquisition of cognitive knowledge or learning development depends upon the child's level of development (p. 30). A final assumption that I made was that the participants would truthfully express their feelings on the pre and post survey and test. The participants would not be pressured by me, or their peers, to give an expected answer during the pre- and post-survey and test.

Limitations and delimitations

This study has the following limitations: (a) the type of sampling method, (b) participants that are categorized as at-risk, (c) the research design, and (d) the limitation associated with using a single school for this study.

In this study, the sampling method that I chose was convenience sampling. This sampling method selects participants who have been grouped into a category prior to this study. This sampling method can only be significant to the group that is being tested. Convenience sampling produces a weak external validity and signs of bias. Johnson and Christensen (2008) stated that "convenience sampling cannot be generalized to a population" (p. 238).

The participants in this convenience sample were distributed by the school system before school started and placed in no particular order. But my school has a high dropout rate and there was a high possibility that the participants might drop out of school or drop out of the study. In this research design, a quasi-experimental nonequivalent group design, I assumed the groups to be nonequivalent, but the convenience sampling may have grouped the students as equivalent groups.

Finally the limitation of using a single school for this study affected any inferences that I made beyond the scope of this study. Some of the participants from this study might have been familiar with me and performed in a way related to my influence instead of the influence made by the interactive technology.

The delimitations in this study were confined to surveying and recording of high school Algebra I students at an urban public high school. The students' ages ranged between 15 and 21 years of age.

Significance of the study

This study was significant in the following areas: (a) it added to the scholarly research about interactive technology in the classroom, (b) it improved existing educational pedagogy related to mathematical education, and (c) it challenged lawmakers or policy writers to invest more money in technological research and technological improvements in the public school system.

In my review of the literature, I described how interactively engaging students in the learning environment can encourage them to participate. For example, Abdulla (2007) suggested, in a study showing students using and manipulating Computer Algebra Systems (CAS), that interactive technology in the classroom promoted mathematical conceptual knowledge while reducing the burden of cumbersome mathematical calculations (p.14). In another research study, computers were successfully used to trigger a higher order thinking process (Tall, 2000, p. 34). Another research study successfully used a Computer Intensive environment (CIE)[e] to enhance the students' understanding of algebraic concepts (Tabach, Arcavi, & Hershkiwitz, 2008, p.53). Although there is research supporting the use of technology, none of the research has explored the use of technology to improve students' success on local, national or

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[e] CIE is a computer intensive environment that allowed students' access to various computerized tools at school and at home on a continuous basis.

international assessment test. Even with all of this research available that could help students' performance on assessment test, the educational system has been very lethargic about incorporating it in the learning environment.

My review of the literature also supports the fact that the United States educational system is still using an educational pedagogy that is the traditional teacher-centered method. Evidence of this was articulated by Stumbo et al. (2005) with the following statement:

We are educating the majority of American students in schools that closely resemble those that our fathers and mothers attended, but students today must succeed in a culture and an economy that has changed dramatically from that of a generation or two ago. (p.1)Jobs in the 21st century are highly technical and they demand that workers have at least some knowledge about algebra, geometry, data interpretation, probability and statistics (Stumbo et al., 2005, p. 2). This pedagogy has existed for years and is showing little progress toward a pedagogy that is linked to 21st century students.

My literature review also revealed few policies that were enacted that would increase mathematical scores on local, state, federal or international achievement test. There was not any federal support of a change in the current educational system to an interactive and computerized system. There were goals and objectives that were supposed to advance all students from being underachievers by the year 2000 but that did not happen (Steen, 2003, p. 79). The NCLB Act of 2001 was supposed to mandate changes regarding mathematical performance from all ethnic groups, but the NCLB lacked the financial structure needed to support the states in this effort toward improving mathematical scores (Steen, 2003, p. 81). The National Mathematics Advisory Panel was created to analyze and make recommendations related to our dismal mathematical scores. The results of those recommendations are yet to be seen. In my research study, I added to the technology-driven research studies, but two additional components, motivation and assessments on achievement test, were be the contributing factors that differentiated my study from others.

The Nature of this Study

I used a quantitative, quasi-experimental design because it gave a broader perspective of the use of interactive technology on test scores and revealed statistically any comparisons or correlations in the data between motivation, test scores, and interactive technology. “A quantitative study according to Reaves (1992) does not deny or ignore personal experiences. It merely insists that these experiences be quantified, measured on some scale, before they can be scientifically studied” (p.16). Mitchell and Jolley (1988) quoted Cook and Campbell (1979) with the following statement about quasi-experimental designs, “quasi-experiments are experiments that have treatments, outcome measures, and experimental units, but do not use random assignment to create the comparisons from which treatment caused change is inferred” (p. 242). Cook and Campbell (1979) further states that “although random assignments create the comparisons from which treatment-caused change is inferred, quasi-experiments creates it’s comparisons on nonequivalent groups that differ from each other in many ways other than the presence of a treatment whose effects are being tested” (p.6).

The dependent variables were the test scores and the numbers generated from the survey tools (see Table 4 for a list of the dependent variables) and the independent variables consisted of the interactive technology. The TI Nspire Calculator was used, by the student, independently, then the TI Nspire Calculators with the navigator and then the E-Instruction clickers was added and used by the students to the previous technologies (see Table 4 for a list of the independent variables).

There I used two methods to collect data in this research study: (a) the questionnaire method, and (b) the testing method. I used the Statistical Package for Social Science (SPSS) Graduate Pack Version 21 to analyze the data I collected from this study. I used SPSS to complete the following analyses: (a) a paired sample t-test analysis of the difference between two means, and (b) a factorial repeated ANOVA.

Social implications of the study

For years the question of improving low mathematical scores on test has intrigued educational leaders. Educators did not predict the impact technology would play on the adolescences of today. Now educators must act, with competitive technology in order to protect careers in mathematics, science and technology. Educators must succeed in bringing the minds of the youth back into the classroom.

The social implications of this study provided a “high tech” approach to teaching 21st century students. Kincheloe and Horn (2007) stated the following about teaching and learning today:

> Knowledge for children in the past generations was finite and limited, but knowledge in the 21st century is infinite. The perceptions about what schooling

> should look like are a mismatch with the reality of today's children. With the need to create effective and engaging pedagogy that addresses the learning needs and styles or students need, we look to learning models that provide student-centered instructions, interactive learning environments, and alternative assessment practices. (p. 284)

The 21st century student is technologically savvy and charged before he or she enters the classroom environment. The students' non educational environment is filled with high tech games and electronics that engage them mentally for hours. I challenged that outside technological stimuli by using a constructivism approach with a nontraditional curriculum that included interactive technology. In this study, I questioned the pedagogical structure in mathematics and maybe this will force theorist to rewrite strategies for teaching and learning mathematics. According to Grassl & Mingus (2002), in their study using the Texas Instruction's graphing calculator, TI 92, in an advanced mathematical classroom:

> Careful selection and creation of more challenging non-routine, yet accessible, problems that lend themselves to technological dissection should be the scaffolding upon which these curricula are built. The final challenge is to recognize and take advantage of the power of technology and to forge a firm foundation for reasoning, convincing and proving in mathematics. (p. 722)

The acceptance of a mandated, new pedagogy with computerized interactive technology would be a milestone in U.S. educational history that could bring mathematics from low performance to above average.

Summary

Low scores on assessment test is the problem that I analyzed by using interactive technology in the mathematics classroom. My assumption were that the students did not participate in the learning because it is boring and it does not compete with the technology the students are using outside of the classroom. The results of this lack of motivation leads to low test scores. These students also do not take advance mathematical classes which could affect their ability to be successful in college and in the market place. Technology was viewed as the stimulus that would intrigue and motivate the students to participate in the learning in the classroom.

The convenience sampling included 76 Algebra 1 students separated into 4 groups: groups A_1 and A_2 – the control groups and B_1 and B_2 – the treatment groups. The low motivation of the students in this study was assumed to be caused by the overstimulation of their senses by outside technology that could not be duplicated in the classroom environment.

My literature review outlined the 21st century use of technology that engaged the learners. I synthesized the literature review with current research in the following areas related to this study: (a) what is known about adolescent learners and motivation, (b) the effects of social change and educational technology, (c) the government initiative to improve learners in mathematics, and (d) technology and current mathematics research.

Organization of the Paper

In chapter 1, I stated the problem and the purpose of this study. I analyzed the theoretical framework and the purpose of this study from the perspective of the theories of Piaget, Seymour Papert, and various authors of the NTCM. In Chapter 2, I investigated the literature review for any relevance to my study. That investigation gave me a better view of the problem and the purpose. I synthesized the literature review and recent studies with the ideas developed in the theoretical framework. Then I critically analyzed the literature review to show areas of gaps and further studies needed, and how my study would contribute to the current research.

In Chapter 3, I outlined the research methodology and described any ethical issues and data reliability and validity. In Chapter 4, I presented the results of the data analysis. Finally in Chapter 5, I summarized the results of my data analysis from Chapter 4 and I conclude my study with recommendations and areas for future studies.

Chapter 2: Literature Review

Introduction

In this literature review, I chronologically synthesized the research from the beginning of the 21st century to the present. The results of this synthesis formed four sections of research analysis: (a) a critical analysis of the research where I focus on an in-depth view of the significance of this study, (b) a critical analysis of the research where I connected social change to technological research in mathematics, (c) a critical analysis of the research where I defined the importance of motivation as a factor that improved test scores, and (d) a critical analysis of the research where I supported technology as a tool in the Algebra environment.

In the first section, my critical analysis of the research that substantiated the importance of this study, different views were gathered and analyzed about the critical state of our educational system and its ranking on an international level. During the majority of the 20th century, the mathematical competence of students in the United States was superior, compared to other nations (National Mathematics Advisory Panel, 2008, p.1). This mathematical achievement included the depth and number of mathematical specialists practicing in the United States, as well as the scale and quality of engineers, scientists, and financial leadership (National Mathematics Advisory Panel, 2008, p.1). Now in the 21st century, the United States' superior engineering, scientific, and mathematical performance is being threatened by its poor educational system (National Mathematics Advisory Panel, 2008, p.1).

The United States tried to control the declining mathematical scores by enacting special legislation to improve its national and international position on assessment test. But recent statistics proved that no solution was found. The National Mathematics Advisory Panel (2008) reported that low mathematical test scores in the United States' educational systems threaten every aspect of the nation, from national security to the quality of life of the people (p.1). The analysis in this section was based on the following two research ideologies related to improving test scores: (a) actively involving students in the learning environment (Serafina and Cicchelli (2003) suggested that students should be actively involved in the learning process by offering them opportunities to explore their own knowledge, use their own reasoning during exploration, and allowing the students time to activate effective problem solving strategies [p.80]), and (b) motivating students during the learning process (the suggestions of the National Mathematics Advisory Panel (2008) revealed that interventions should be established that address student behavior issues related to social, affective and motivational factors [p.1]). In the second section, I provide a critical analysis of the research that connected social change to technology research in mathematics. I focused on two areas related to social change in a social institution: (a) the need for a new pedagogical strategy that broadens the minds of students, and (b) the need to close the digital divide by developing all students for a better society.

In the third section, I conduct a critical analysis of the research that defined the importance of motivation as a factor that improved test scores. Five research studies were analyzed and synthesized. In the introduction of this section, motivation was validated as a key component for engaging students in the learning environment. The first analysis linked motivation to two types of achievement goals: (a) mastery goals, and (b) performance goals. In the second analysis, I examined the interaction between attitudes, motivation and second language learning. The third analysis analyzed the effects of a web-based course as a motivational tool to engage at-risk students. The fourth analysis on motivational factors and technology investigated a comparative analysis between two interactive technology systems and identified the system that was the most effective system for engaging students as active participants in an authentic scientific environment. The final analysis assessed the effective use of the Motivated Strategies for Learning Questionnaire (MSLQ) as a reliable pedagogical tool for measuring motivation. The results of these studies confirmed the use of technology as a tool to engage, excite, and motivate students in the learning process.

The last section of this literature review focused on a critical analysis of the research that supported technology as a tool in a mathematical environment. This section took a chronological perspective of the research in the 21st century and synthesized three areas of significance: (a) research based on using computers as a CAS, (b) research based on using calculators as a CAS, and (c) research based on the simultaneous manipulation of the computer and the calculator as a CAS.

A Timeline of Mediocrity

Twenty years ago, the United States realized that its educational system was struggling in mathematics and science (Steen, 2003, p.79; National Mathematics Advisory Panel, 2008, p. xii). Mathematicians and mathematics educators were so alarmed by the dismal results from a major international assessment in mathematics that they decided to coordinate their efforts to move mathematics education in a direction toward achievement (Steen, 2003, p.79). The president and state governors formed a committee that would adopt six, national goals. One of those goals would help teachers to rank the mathematics and science students as the top students in the world by the year 2000 (Steen, 2003, p. 79). That goal was not met and the failure to reach that goal prompted the National Assessment of Educational Progress report (NAEP) to make the following statement: “the students’ performance in mathematical problem solving still remains dismal and shows little evidence of the students’ understanding of mathematical concepts” (Serafino & Cicchelli, 2003, p. 79).

After much debate and concern in Congress about the failing educational system, a new legislation was enacted called No Child Left Behind (NCLB). NCLB was the first and most powerful legislation ever imposed by the federal government that mandated educational standards for Grades K through 12 (p. 81). Schools nationwide were to perform annual testing of students in Grades 3 through 8 and in the eleventh grade to comply with NCLB. If the schools did not demonstrate annual improvements, various sanctions were imposed on the schools and possible school closure would be a final result. The harsh regulations of the NCLB caused the government, at the states level, to establish content standards in mathematics and science. These content standards would also require students to take more than two years of math and science. The NCLB imposed many regulations but no government financial support was available to assist with its complete implementation. Today, the local educational system has yet to see any “financial muscle” from the NCLB and our nation is still lagging behind other nations.

Researchers have shown that U.S. students have stagnated on their performance on national test even though they receive the same amount of instruction on mathematics and science and spend the same amount of time on homework; U. S. students' performance is still substandard; the gap between the high performing students and the low performing students is enormous; racial and ethnic gaps are even larger; low socioeconomic groups perform poorly; and overall U.S. students are still uncompetitive internationally (Steen, 2003, p.80). The National Mathematics Advisory Panel (2008) confirmed, in their report, that the large gaps in mathematics achievement related to race and income is devastating to individuals and families and reflects negatively on our nations as the minority populations continue to increase at a phenomenal growth rate (p. xii).

The results from the Program for International Assessment (PISA)[f] indicated that the U.S. ranked 24th out of 29 countries on the math section, the U.S. has not closed the enormous gap in student achievement in mathematics or science, and the national goal of making the U.S. students the first in the world in math and science has not been accomplished (Bybee and Stage, 2005, p. 69). Bybee and Stage (2005) indicated three areas of educational reform that could remove mathematics from underachievement: (a) there must be continuous support and encouragement for innovations in science and mathematics programs, (b) There must be continuous support and encouragement that identify the next generation of innovations aimed at enhancing learning, and (c) there

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[f] The PISA is an international assessment test that tests 15-year olds from 41 countries in 3 categories: (a) literacy in reading, (b) mathematics, and (c) science.

must be continuous support and encouragement that targets professional development of teachers in areas of innovative ways of teaching and learning (p. 78).

The continued reports concerning low academic performance in mathematics, prompt President George Bush to create an advisory panel called the National Mathematics Advisory Panel, with the sole responsibility of using the best available scientific evidence to make recommendations on how to improve performance in mathematics among American students (National Mathematics Advisory Panel, 2008, p. 7). In a 120 page report called “The Final Report of the National Mathematics Advisory Panel,” the National Mathematics Advisory Panel (2008) made recommendations in 7 areas:

- (a) curricular content,
- (b)learning processes,
- (c) teachers and teacher education,
- (d) instructional practices,
- (e)instructional materials,
- (f) assessment, and
- (g) research policies and mechanisms. (p. xvi)

Integrated throughout all of the recommendations was the Algebra knowledge or Algebra competences. The National Mathematics Advisory Panel (2008) believed that Algebra is a central concern in high school math because Algebra knowledge represents the foundational knowledge needed for student’s success in advance mathematical courses (p.xiii). The United States’ misguided understanding of mathematical education has focused on the nation' economics perspective that is related to national competitiveness and enterprises; but in fact, low mathematical scores could affect the safety of the United States, the quality of the citizen's life, and most importantly, the prosperity of our nation (The National Mathematics Advisory Panel, 2008, p.1).

The goal of this study was to use interactive technology to enhance student's learning and improve their performance on local and national assessment. Using interactive technology supported a constructivist theory that states where "cognitive processes are enhanced when students are actively engaged in learning activities that involve construction of their own knowledge through exploration, reasoning, and the application of problem solving strategies" (Serafino & Cicchelli, 2003, p. 80). The knowledge from this study was aimed at enabling research that would identify the next generation of innovations that may enhance learning and involvement in the mathematical classroom. The knowledge gained from student's enhanced learning and involvement in the mathematical classroom could result in high test scores.

According to my review of the literature, improving mathematical assessment is a national problem, with no definitive solution that might improve the situation.
Stumbo, Circe, and Lusi, (2005) stated that mathematical knowledge is not only crucial for individual success, it is also crucial for the future of our nation because in the next 15 years, 3.3 million jobs will move to East Asia—not because of cheap labor, but because other countries are educating more of their workers to perform in a high skilled environment (p. 2).

It is possible to end this time of low mathematical achievement by creating, developing and supporting research that motivates and interactively engage students to cognitively participate in the learning environment. The results of this energetic participation in the learning environment could yield excellent test scores on local, national, and international achievement test.

Technological Research and Social Change

The understanding of technological research in education and social change can only be accomplished by first defining social change. Pinquart and Silbereisen (2005) defined social change by quoting Calhoun (1992) with the following statement: "in broad terms, social change can be defined as changes in the typical characteristics of a society, such as the economic system, social institutions, cultural products, laws, norms, values, and symbols" (p. 396). This definition makes the educational system a social institution and any changes that affect the educational system, affects social change. Technology education can become an agent of social change if its goals are to broaden the minds of students and develop the students to create a better society (Pavlova, 2005, p. 199). This research study, using interactive technology in the mathematical classroom to increase test scores, could only be accomplished by focusing on broadening the students minds and developing all students for a better society.

There are two areas that I have identified in this literature review that could affect social change: (a) this study could create a pedagogical strategy that could be an effective way of engaging students by increasing their test scores and increasing their interest in advanced mathematics, and (b) this study could reduce the social inequalities in educational participation by reducing the digital divide. In the first area, creating a new pedagogical strategy to be used in the 21st century, an analysis was made of the prevailing pedagogical strategies in use today. That analysis revealed an approach called *direct instruction* or *teacher-centered pedagogy*. The definition of direct instruction or teacher-centered pedagogy instruction means that the teacher is in command of the teaching and the learning while students watch, listen and then practice the methods (Boaler, 2008, p. 589). Direct instruction or teacher-centered pedagogy are the same teaching strategies that were used to teacher our parents and grandparents. Direct instruction has been proven to be effective when teaching factual content but direct instruction woud not enable students to process or transfer that knowledge to higher order cognitive skills like reasoning and problem solving (Paslincsar, 1998, p. 347; Peterson & Walberg, 1979). Students today are different and need different teaching and learning strategies (Stumbo, Circe, & Lusi, 2005 p. 239).

Although direct instruction has a purpose in the daily instructions of mathematics, the type of instructions needed in the classroom should promote high level of cognitive skills, reasoning, and problem solving. Advanced levels of cognitive skills, reasoning, and problem solving will supplement the foundational knowledge needed for success on assessment test and success in advance mathematical courses. In this study the use of interactive technology took a social constructivist[g] approach by using technology as a tool to motivate and engage students to participate in the learning environment. From the

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[g] Social constructivism is the study of the interdependence of social and individual processes in the co-construction of knowledge.

social constructivist's perspective, if the learner is engaged in the learning process their attention span is improved which correspondingly improves overall learning as the teacher created activities direct the students toward mastery and cultural assimilation of knowledge (Hyslop-Margison & Strobel, 2008, p. 81).

In the second area, reduction of the digital divide or the social inequalities in the educational system, President Bill Clinton stated the following in his State of the Union Address in 2000, "opportunity for all requires something else today—having access to a computer and knowing how to use it; this means that we must close the digital divide between those who have got the tools and those who do not" (Selwyn, Gorard, & Williams, 2001, p. 259). If technology is viewed as a key that would reduce the digital divide, then technological advancements in education could have social effects. Technology has permeated our social environment and has made itself a social structure. That social structure known as a "technological forms of social life" is a form of social action and a part of the norms of any action (Pavlova, 2005, p. 204; Böhme, 1992).

Interactive technology, in my study, used with participants that are techno savvy when it relates to high tech games and the use of cell phones. However, many of the participants did not have computers in their homes or they did have computers but did not have access to the Internet. The use of multiple forms of technology for improving students' motivation and test scores in this study, added to the research on educational technology by focusing on educational methods that address social needs.

Technology in education has made many researchers conclude that patterns of sustained learning can reduce levels of social exclusion in education and foster lifelong learning practices (Selwyn et al, 2001, p.259). Selwyn et al. (2001) also quoted Harrison (1993) with the following statement concerning lifelong learning: “there are barriers faced by potential participants in lifelong learning that are classified into the following 3 groups: situational (to do with lifestyle), institutional (related to the opportunities available), and dispositional (personal knowledge and motivation)” (p. 264). Two of these barriers were addressed in my study: (a) institutional – where the students were given opportunities to use and learn with technology, and (b) dispositional – where the students used the interactive technology to raise their levels of personal knowledge and self-worth.

Technological Research and Motivation

Several research studies that supported the role of motivation to improve test scores were analyzed. Before this analysis could be accomplished, researchers explored the visual aspects of motivation in a learning environment. For example, *motivated instruction* is a process where goal-directed activities are activated by the instructions and self-supported by the students (Eklöf, 2007, p. 312; Pintrich & Schunk, 2002, p. 5). Another example defined the relationship between motivation and test scores or *test-taking motivation* as the willingness to persistently perform well on test item (Eklöf, 2007, p.312; Baumert and Demmrich, 2001, p. 441). Masgoret and Gardner (2003) defined the motivated individual with the following statement:

> The motivated individual expends effort, is persistent and attentive to the task at hand, has goals, desires, and aspirations, enjoys the activity, experiences reinforcement from success and disappointment from failure, makes attributions

concerning success and/or failure, is aroused, and makes use of strategies to aid in achieving goals (p. 128).

Motivation can be linked to test scores if students are provided with interventions that address social, affective, and motivational factors in racial groups that are underrepresented in mathematical fields (National Mathematics Advisory Panel, 2008, p. 32). The interventions for this group must focus on increasing the student involving in task in the mathematical classroom and improvement in the student's self-efficacy.[h] (The National Mathematics Advisory Panel, 2008, p. 32)

In the first meta-analysis on motivational factors, achievement goals and motivation were analyzed. There were two types of achievement goals that promoted an optimal level of motivation in students: (a) mastery goals and (b) performance goals. In mastery goals, students are motivated by the desire to acquire new knowledge and skills or simply a basic understanding of the material. In performance goals, students are motivated by the desire that they have demonstrated competence relative to others or simply students strived just to do better than the other students (Barron & Harackiewicz, 2001, p. 706). Previous research has proven that mastery goals compared to performance goals have the best outcome for optimal motivation but this study by Barrron and Harackiewicz, offered a comprehensive test of the mastery versus multiple goal perspective (Barron & Harackiewicz, 2001 p. 710). Barron and Harackiewicz (2001) selected 79 men and 87 women as participants, from a pool of introductory psychology undergraduate majors (p.710). The participants were given a survey that assessed their

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[h] Self-efficacy is the theory that relates to a person's belief in himself and his academic performance.

achievement orientation and gender, and then the participants were assigned to one of two cohorts. “In the first cohort, college students’ self-set achievement goals were measured and evaluated correlationally, and in the second cohort, college students’ achievement goals were manipulated or assigned and evaluated experimentally” (Barron & Harackiewicz, 2001 p. 710).

The procedure, for both cohorts, consisted of first having the participants sign a consent form that stated that they would be learning new math techniques that rethink approaches traditionally taught in schools (Barron & Harackiewicz, 2001 p. 710). Next the participants were given a pre-test that measured the current method of solving mathematical problems. The rest of the instructions were given using an audiotape that guided the participants through the new math techniques. Finally the researchers administered a post-test where the participants only used the new techniques to solve the problems. Two different sets of problems were given in the post-test; one set of problems, given to 50% of the participants, were similar to the lesson taught, while the other set of problems were dissimilar and very difficult. The first set of problems were actually designed to provide the first group with a high level of success while they were experiencing the new technique or treatment. The second group experienced the difficulty condition and the first group experienced the success condition (Barron & Harackiewicz, 2001 p. 710).

The results of the first cohort proved that when students self-set their mastery and performance goals they tend to become interested in the task and perform well in the learning session (Barron & Harackiewicz, 2001 p. 711). The results of the second cohort suggested that by manipulating the achievement goals the student's achievement could increase but it depended on the student's goal orientation (Barron & Harackiewicz, 2001 p. 714). "Evidence supporting a multiple goal perspective may appear in a number of different forms, especially depending on whether the goals are self-set by the individual or assigned by others" (Barron & Harackiewicz, 2001 p. 714).

The conclusion of this study stated that optimal motivation can be accomplished by using a multi goal perspective that allows mastery and performance goals to be produced. This multi-goal perspective allowed for a more sustainable level of motivation compared to just using a mastery goal perspective or a single performance goal perspective. Barron and Harackiewicz (2008) proved that when using techniques that motivate students to want to learn and at the same time motivate the students to be competitive in their learning, successful results on assessment test was maximized (p.720). The employment of various interactive technologies was manipulated in an attempt to motivate the students to be successful in the learning environment.

In the second meta-analysis on motivational factors, Masgoret and Gardner investigated the interaction between attitudes, motivation, and second language learning. Masgoret and Gardner (2003) identified 5 attitude/motivational variables displayed by second language learners: (a) integrativeness – which refers to the ability of the student to identify with a different culture and it's language, (b) attitudes toward the learning situation – which is the individual's reactions and feeling about the context of that different culture's language, (c) motivation – which is a goal-directed behavior that positively impact the student's behavior compared to the unmotivated individual, (d) integrative motivation – which is the interaction between integrativeness, attitudes toward the learning situation and motivation, and (e) instrumental orientation – which defines the reasons a student pursues a second language (pp. 126-129).

There were three hypotheses that were developed and based on an attitude/motivational model: (a) the first hypothesis tested the relationship that existed between attitudes, motivation, and orientation and second language achievement, (b)the second hypothesis tested the sociocultural influences that may have existed between attitudes, motivation and orientation, and second language achievement, and (c) the third and final hypothesis tested any influence between age and experience on the 3 variables of attitude, motivation and orientation on second language achievement (Masgoret & Gardner, 2003, p. 130).

The research method used by was a meta-analysis of 75 independent samples of data involving 10,489 participants. These samples of data contained 21 samples of participants learning the language in a second language context, and 54 participants learning the language in a foreign language context. The samples were broken down into classes of students; 16 elementary students, 42 secondary students, and 13 university level students. The participants were given the Attitude/Motivation Test Battery (AMTB) which was comprised of 11 subtests and various measures of second language achievement test.

This research study concluded the following information: (a) there was a positive correlation between the 5 variables, attitude, integrativeness, motivation, integrative orientation, instrumental orientation, and the achievement in a second language, (b) motivation and second language achievement had more of a direct relationship than the other variables, and (c) the age and experience had no influenced on second language achievement (Masgoret & Gardner, 2003, p. 158). The use of the Attitude/Motivation Test Battery (AMTB) to measure the relationship between integrativeness, attitudes toward the learning situation and motivation proved that motivation was a contributing factor for the participant’s achievement in the second language acquisition.

There were also several critiques noted in other research studies about the use of the AMTB. One critique of the AMTB was that it was difficult to decide whether the motivated instrument or the motivated behavior was being measured (Dörnyei, 2001; Huang, 2008, p. 529). Another critique by Huang (2008) was that the AMTB is effective as a social tool for measuring social interaction between the students and their culture (Huang, 2008, p. 530).

This study by Masgoret and Gardner (2008) was related mostly to the actual learning of a second language and how different variables interact to increase the participants’ acquisition of a second language. Since motivation was a contributing factor in the students’ achievement in the Masgoret and Gardner study, then a motivational survey was used in my study to analyze any influences between motivation, interactive technology, and test scores.

In the third meta-analysis on motivational factors, at-risk students were challenged to improve their engagement by using a web-based course as a motivational tool. Lehman, Kaffman, White, Horn and Bruning (2001) reviewed the literature of an exploratory study by the “Center for Instructional Innovation” and found that there was huge difference between the performance of at-risk students compared to the not at-risk students, even though the at-risk students had extra help and received monetary incentives (p. 2). The results from the exploratory study by the Center for Instructional Innovations, led Lehman et al. to investigate the effects of variations in teacher-student interaction on at-risk students' engagement in Web-based courses. Two dimensions of teacher-student interactions were manipulated by Lehman et al. that would enhance student motivation and engagement: (a) motivational-building and (b) personalized caring interactions. The motivational building focused on changing the students' beliefs regarding themselves and their academic performance while the personalized caring interactions focused on enhancing the student teacher relationship during delivery of instruction. A deeper analysis of "personalized caring" suggest that teachers should care for their students success and care about whether the student is succeeding in the classroom. "Social and psychological literature has presented evidence supporting the need for belonging (i.e. a caring relationship that extends over time) that motivates human behavior to the extent that it constitutes a fundamental human motivation" (Lehmen et al., 2001, p. 4). Lehmen et al. (2001) proceeded with their study by selecting 16, at-risk participants (13 females, 3 males) and randomly assigning them to one of four conditions within a two by two design as shown in Table 1.

Table 1

Personal vs. Motivational Building

Type of investment	Level of motivation	Personal investment	Motivation building
		Low	High
Personal investment	Low	Baseline professional	Motivating professional
Motivation building	High	Invested professional	Motivating, invested professional

The participants in the “personal investment” category received either low or high responses that indicated the teacher had a personal investment in their success. Teachers focusing on the “baseline professional” level would display little or no concern for the students’ success when responding to their assignments; but the “invested professional” focused on making statement of concern that prompt the students to probe deeper into their assignments.

The participants in the “motivated building” category received either low or high responses that represented motivational desires from the teacher. Key words like, “good job,” “well done” or stellar performance” as feedback on students’ assignments would encourage the participants probe deeper into their assignments. Teachers working in the low “motivating professional” level use little or no words that would motivate the students; but the teachers working in the high and “motivating, invested professional gave feedback to the participants using motivational and invested professional key words that gave the students a feeling of self-worth and genuine concern from the teacher toward their performance on assignments (Lehman et al., 2001, p. 6).

The results of this study indicated that enhancing teacher-student interactions showed promising results that might successfully increase at-risk students' success rates in a Web-based course. But the small sample size limited the study from making accurate conclusions based on the analysis of the data. Lehman et al. (2001) made the following statement based on firsthand observations of students engaging in a beginning composition course, "motivation building instead of personal investment may be more effective in enhancing engagement with at-risk students" (p. 15). Although the content of this study is different from my study, motivational building was noted as a factor for engaging and enhancing student success among at-risk students. Lehman et al. also validates the use of motivational tools to measure the engagement of students.

In the fourth meta-analysis on motivational factors and technology, a comparative analysis was performed between 2 types of small computer systems used for participatory simulations in a scientific classroom. Participatory simulations allowed students to observe and participate in a simulation, where they recorded and discussed their findings of scientific concepts. The 2 types of small computer systems used in this study were the *Palm* (with participatory simulations software) and the *Thinking Tags* (the original tag-based simulations software that had demonstrative success helping students to work collaboratively solving complex problem situations ;Klopfer, Yoon, & Rivas, 2004, p. 347).

Thinking tags are badges that are the size of a name tag with an electronic circuit attached to the back of it. Its main feature is to send and receive Infrared communication between devices. The Thinking Tags allowed the students to become active participants in the simulation by engaging them in inquiry, collaboration, data analysis and authentic scientific methodology.

The thinking tags provided many learning benefits and very few limitations. The following learning benefits were produced from using the Thinking Tags: (a) the students were captivated and motivated by the technology to participant in the learning environment, (b) the technology supported student interaction and collaboration in order to resolve the problem situation, (c) the use of technology engaged the students to interact with each other regardless of the gender or background of the students, and (d) finally but most importantly the technology made the students excited, they enjoyed learning, and they were satisfied with their learning experiences (Klopfer et al., 2004, p. 349). But the following limitations prevented the "thinking tags" from becoming widely distributed: (a) high cost, (b) low durability, and (c) difficulties in programming.

The many features of the Palm made it more desirable than the "Think Tags." Those features included the Palm's PDA capabilities, its cost, its ability for sampling scientific data, graphing and computations, concept mapping, and information gathering utilities. The Palm also enhanced the students' understanding of concepts and helped them to construct knowledge. But can the Palm with its participatory simulation software produce the enthusiasm, personal involvement, and desire to study like the "Think Tags?"

The participants in this study were taken from 1 middle school and 2 high schools. The high school students were taken from biology classes, where they range in ages between 14 and 16 years old. The middle school students were taken from science classes, where they ranged in ages between 11 and 13 years old. One of the high schools was a public school of 71 students in 4 classes, and the other high school was a private school of 117 students in 6 classes. The middle school was a private school where 82 participants were selected from 5 classes. The time duration of this study was two 50 min class periods, given in either consecutive weeks or back-to-back class periods. “The data collected included pre-and post-activity surveys, video analysis of the classes, individual behavioral observations, teacher interviews, and real-time summaries of class strategies” (Klopfer et al., 2004, p. 353).

The results of this study did not show any significant difference in the participatory simulations on the Palms compared to the participatory simulations on the Think Tags. Both tools did act as a motivator by exciting the students to become involved in the learning environment. The less costly technology would probably be the best choice.

This study did prove that technology can be used as a motivating factor for engaging students or a motivating factor for getting students involved in a scientific environment not a mathematical environment. This study took a qualitative approach to analyzing the data while my study took a quantitative approach. This study focused on students’ motivation, interest, and excitement, but this study did not present any statistical analysis that motivation, interest, or excitement in the learning environment would transfer to test scores or any type of assessment.

In the final meta-analysis on motivational factors that might improve test scores, motivation is assessed using the Motivated Strategies for Learning Questionnaire (MSLQ) to compare the similarities and differences in general education and the foreign language (L2)[i] learning context (Huang, 2008, p. 531). Huang (2008) quoted Gardner, Tremblay, and Masqoret (1997) and Dörnyei (2001) by stating that “motivation has generally been considered to be an important factor in student learning and achievement that is not directly observable but can be measured by using self-report questionnaires” (p. 529).

The MSLQ is an 81-item questionnaire that consists of 6 motivational and 9 cognitive subscales that are used for measuring motivation. The MSLQ has been used worldwide by hundreds of researchers and instructors. Over 50 empirical studies, covering various content areas and populations have been published during the period between 2000 and 2004.

In this particular study by Huang (2008) which was conducted over an 18 week period, students were selected from the University of Taiwan who had received more than 8 years of formal English instruction. These student or participants consisted of 121 college freshmen, 33 females and 88 males. During the fourth week of the study, the MSLQ was given to the participants in their native language and a General English Proficiency Test (GEPT) was given to measure the participants’ reading and listening proficiency. “In the final eighteenth week, based on the content of the course, students were tested one-on-one for their achievement in English speaking ability, following the short-answer question format of GEPT” (Huang, 2008).

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[i] L2 indicates second language or the language after the mother language has been learned.

The results of this study proved that the MSLQ seem to be a feasible pedagogical survey tool in foreign language context and possibly a feasible pedagogical survey tool in any context for measuring motivation. Huang (2008) also stated that "the self-efficacy component of the MSLQ is the most valuable because self-efficacy is a critical factor that indicates whether the students are engage in the learning activity" (p. 533).

In all of the analysis in this section, motivation proved to be a key component for engaging students in the learning process. However none of the research studies presented a relationship between motivations that transformed into test results. In my study, a relationship between motivation and test scores was analyzed using interactive technology as a motivator and measuring that motivational factor using the MSLQ.

Technological Research in Mathematics

In this section the research was summarized, critically analyzed, and synthesized from the beginning of the 21st century to the present. During this analysis, 3 areas of research were identified: (a) the research that focused on computer based technology and mathematics, (b) the research that focused on calculator based technology and mathematics, and (c) the research that focused on combining computer based technology and calculator based technology within a mathematical environment.

Computer Based Research as a Computer Algebra System

In this section, there were nine research studies in an Algebra environment that used computer based software as a Computer Algebra System (CAS). The synthesis of this research formed 4 analysis that focused on the following problem areas: (a) improving the thinking process of students within a computer based environment, (b) using a specific teaching strategy within a computer based environment, (c) heightening student-control over the learning environment with a computer based environment, (d) algebra remediation using a computer based environment, and (e) a comparison of a computer based environment and a traditional approach to teaching.

Improving the thinking process of students. The two research studies in this section analyzed methods to improve the thinking process of students in an Algebra setting. The first research analysis used computer based lessons to free the mind of repetitive and tedious mathematical task while enabling or enhancing the conceptual thinking process of the brain. The second research analysis used computer based lessons to help students in an Algebra classroom to transition their thinking process from an arithmetic method to an algebraic method.

In the first study, a researcher by the name of David Tall used an empirical research method to explore the following: how a computerized environment enhances and encourages versatile thinking and the results of using computers positively and negatively in a mathematical setting (Tall, 2000, p. 33). During the early 21st century, math educators still viewed technology, specifically calculators, as the tool that would remove the tediousness of calculations and allow the users to focus more on the essential ideas and concepts behind the calculations (Tall, 2000, p. 34). The integration of technology and the "versatile thinking process" would form the bases of the essential ideas needed in arithmetic, algebra and calculus (Tall, 2000, p. 33). "Versatile thinking, according to Tall (2000) is the ability of individuals to move freely and easily between a sequential/verbal-symbolic mode of thinking and a more primitive holistic visuo-spatial sense of thinking" (p. 33).

Tall (2000) hypothesized that "the best way to use computer software in supporting mathematical learning is to use arithmetic computation and symbolic manipulations that would allow the brain to use visually presented results to see conceptual linkages" (p. 34). Too much use of technology or the calculator could hinder students' use of basic task and force the use of calculators to become just sequences of button presses. But if the students develop a conceptual understanding of the task during the use of calculators then the use of calculators would serve as an advantage rather than a disadvantage (Tall, 2000, p. 48). The results of this conceptual knowledge could be used during future testing and future mathematical classes.

The results from this research study were based on an analysis of previous studies. Tall first quoted the research by Sun (1993) to show the negative side of technology: "Sun proved that 16 and 17 year old students using a mathematical software product to an extreme extend, were mentally disabled to perform previous 'pencil and paper' task performed before the study" (p. 34). Tall then analyzed the research by DeMarois (1998), who worked with students using graphing calculators in a remedial college pre-algebra course, to show how technology could enable different levels of thinking.

Three levels of thinking emerged from this study: (a) the procedural level of thinking which identified students using a finite succession of actions and decisions during the problem solving phase, (b) the process level of thinking identified students that were focused on inputs and outputs instead of the process that it took to achieve a given result, and (c) the precept level of thinking which is the preferred thinking level, identified students engaged in thinking during the problem solving phase (Tall, 2000, p. 37; DeMarois, 1998). In the procept stage the versatile thinking process is triggered. Tall provided evidence of the negative and the positive side of using calculator technology and the ability of technology to trigger a higher order thinking process. But no evidence however, was linked to whether that actual process occurred. No evidence was provided that would link computer technology to motivation or test scores.

In the second analysis related to improving the thinking process of students, Tabach, Arcavi, and Hershkiwitz (2008) stated the following, “the transition from arithmetic to algebra in general, and the use of symbolic generalizations in particular, are a major challenge for beginning algebra students” (p. 53). This probably is why the National Mathematics Advisory Panel (2008) has a section in their final report specifically addressing the difficulties related to learning Algebra (p. 32). In this study by Tabach et al. (2008), 2 cohorts of seventh grade students, during 2 consecutive school years, were observed and analyzed to better understand their learning processes in a computer intensive environment (CIE). A CIE is a learning environment where the students have access to various computerized tools continuously in the classroom and at home. The students were also given the choice to use the tools whenever necessary (p. 53).

Tabach et al. (2008) framed their study around 3 research questions: (a) what is the working style of the students before CIE and what type of symbolic methods are observed, (b) Do the students working style and symbolic methods change while working in a CIE with spreadsheets? Describe any changes observed and (c) can the students transform themselves from the CIE and spreadsheet environment to a fully functional paper and pencil method using symbolic expressions (p.58)

The setting of this study took place in a school for advanced students. There were 52 participants, selected from 3 classrooms and placed in 26 pairs. The 26 pairs of students were divided into 2 cohorts with the following characteristics: (a) the treatment or experimental group which learned the beginning algebra course with CIE and (b) the control group which learned the beginning algebra course in a partially computerized environment with Excel. The Excel spreadsheet served as a mediator to help the students understand and construct symbolic generalizations. Tabach et al. (2008) quoted Haspekian (2005) by stating the following about the use of spreadsheets, "spreadsheets allowed students to observe, handle, and generate a large number of numerical instances, and thus to potentially bridge the sometimes rapid and disconcerting transition from numbers to symbols, form arithmetic to algebra" (p. 56).

Data was collected twice during the two year study period, using one group per year. The results of the data was analyzed and grouped into 4 categories that defined the students' problem solving strategies. The 4 categories were: (a) numerical generalizations – when students used basic symbolic relationships between numbers, (b) multi-variable generalizations – when students considered a whole array of numbers as a variable, (c) recursive generalizations – when students used recursive expressions to represent relationships between variables, and (d) explicit generalizations – when students expressed and displayed the general and full relationships between variables (Tabach et al., 2008, p. 59).

The results of this study revealed that students used a variety of strategies in solving problems related to realistic situations. During the study, the students used more sophisticated strategies like recursive generalizations during problem solving. This proved that the students did make the transition from arithmetic to algebra. The final observation from the data showed that most students also made the transition from spreadsheets to a pencil and paper environment.

This study tested the transition of students' strategies in a computer intensive environment but this study did not prove or test any relationship between strategies and test scores. Whether any of the 4 strategies would lead to success in a testing environment was not indicated. The control group was given partial treatment, instead of no treatment. The selection process was not mentioned in this study.

Although improving the "thinking process" of students could be an important first step to improving test scores, no relationship between the "thinking process" of students and "test scores" was implicitly or explicitly presented by the 2 research studies.

Teaching strategies. In the next 3 research studies, certain teaching strategies were used as a means to enhance learning with computer based technology. In the first study, teaching strategies were used with computer projects. In the second study, a strategy called meta-cognitive training was used with computers and in the final study a discovery method was used with computer technology.

In the first analysis, a research study was conducted using a college linear algebra course, computer projects and teaching strategies that would promote critical thinking and increased communication between the students and teachers (Pecuch-Herrero, 2000, p. 181). LINALG, a menu-driven program developed by a team at the University of Arizona, was adopted as the resource for the computer projects because of its user-friendliness and its permission to be used freely for educational purposes.

The LINALG computerized curriculum provided the following advantages: (a) it introduced the student to new knowledge about linear algebra using hands-on activities, (b) it used activities that presented new definitions related to linear algebra, (c) it used activities that demonstrated new theorems and their usefulness in solving various problems, (d) it used activities that demonstrated the use of conjectures, and (e) the LINALG software could be modified and used with any linear algebra software (Pecuch-Herrero, 2000, p. 181).

Based upon the advantages of the LINALG computerized curriculum, several teaching strategies were implemented; (a) new concept exploration would be initiated using LINALG, (b) the teaching of the concept of "linear transformations" was moved to being taught in the middle of the course as opposed to the end of the course, (c) integrating some geometric concepts into the algebra lesson that would enforce a better understanding of the algebraic concepts, (d) engaging the students to practice portfolio learning, and (e) using computer based projects and applications to motivate students (Pecuch-Herrero, 2000, p. 182).

The analysis of this study compared the final grades for the students over a 3 year period. In the first year, when no computers were available and the teaching strategy followed a traditional order, 62% of the students made either an “A” or “B”, 23% made either a “C” or “D”, and 15% of the students made an “F”. In the second year, where classes were held in a computer lab and the students performed exploratory work with linear algebra computer programs, 59% of the students made either an “A” or “B”, 24% made either a “C” or “D”, and 18% of the students made an “F”. In the third year, this study was fully conducted using the outlined teaching strategies and the computer projects. The results during that third year yield 75% of the students made either an “A” or “B”, 22% made either a “C” or “D”, and 3% of the students made an “F”.

The analysis yield the following results: (a) increased cooperation among students – probably motivated by the need to discuss proofs and writing requirement,
(b) higher grades – increased by 16% over the previous year, and (c) a decrease in failing grades – by 15% (Pecuch-Herrero, 2000, p. 182).

Pecuch-Herrero concluded that improvement in learning was due to the combination of the teaching strategies rather than the use of technology. Although this study used a specific teaching strategy and a specific software program with computers to improve college level students’ test scores and final grades, the researcher could not say what portion of that grade was based purely on technology. Pecuch-Herrero should have isolated the variables, the teaching strategy and the technology, to analyze the effectiveness of each.

In the second study, the effects of a Computer Algebra System (CAS) with meta-cognitive training on mathematical reasoning was analyzed. The definition of meta-cognition can be defined using the following 3 examples; (a) meta-cognition is the knowledge about one's own thought processes, (e.g., How accurate are you in describing and analyzing how you think or your process of thinking), (b) meta-cognition is the act of controlling or self-regulating your own thought processes (e.g., Can you write down or remember the steps or tasks you used when solving problems), and finally (c)meta-cognition is the beliefs and intuitions that interact with your thought processes (e.g., What idea have your brought with you about mathematics) (Kramarshi & Hirsch, 2003, p. 250; Schoenfeld, 1987).

The meta-cognitive training in this study was based on the IMPROVE method. The IMPROVE method used the following teaching and learning sequence: (a) whole class instruction of new material, (b) questioning techniques that activate mega-cognition, (c) practicing the new concept, (d) reviewing the strategies of the new concept, (e) obtaining mastery on all cognitive competences, and (f) verifying the solution and using enrichment materials to enhance learning (Kramarshi & Hirsch, 2003, p. 251). The CAS training, with meta-cognitive strategies, would include 20 hours of computer instruction in a computer lab each week for 1 hour. The CAS with meta-cognitive strategies would also be designed using a series of questions, called the self-questioning approach. This self-questioning approach would focus on questions related to: (a) comprehension of the problem situation, (b) connecting new and prior knowledge (c) using strategies that are appropriate for the specific problem situation, and (d) summarizing and reflecting on the specific processes and solutions (Kramarski & Hirsch, 2003, p. 250).

The participants in this study consisted of 83 eighth grade students randomly selected from 4 classrooms in 4 different junior high schools. All of the students studied Algebra, 5 times a week during a 5 month period. The students were divided into 4 groups using 4 different instructional methods: Group 1 contained the students using CAS only, Group 2 contained the students using CAS + META, Group 3 contained the students using META only, and Group 4 contained the students using neither method (CONT).

This study analyzed 3 areas: (a) prior mathematical knowledge, (b) mathematical reasoning, and (c) meta-cognitive knowledge. Mathematical prior knowledge was measured by administering a 21 question pre-test at the beginning of the school year that covered operations with positive and negative numbers, order of operations, the basic laws of mathematical operations, algebraic expressions, and open-ended computational problems (Kramarski & Hirsch, 2003 p. 252). Mathematical reasoning was measured using a 17 item post-test that was based on the student's algebraic techniques, algebraic reasoning, algebraic patterns, and changes related to algebraic functions. Meta-cognitive knowledge would be tested by the administration using a questionnaire adopted from the study of Montague and Bos (1990) and Kramarski, Mevarech and Liberman (2001).

The results of this study suggested the following: (a) a computer algebra system using meta-cognitive condition produced the most significant improvement and outperformed the other variables, (b) no significant difference were produced between the meta-cognition or computer algebra systems when used or tested independently, (c) a computer algebra system with meta-cognition indicated the best results, meta-cognition only study indicated second above the group using just CAS and the CONT groups (Kramarski & Hirsch, 2003 p. 253). Kramarski and Hirsch proved that CAS does improve students' mathematical reasoning. But when META is added students show a substantial improvement in mathematical reasoning and problem solving.

In Kramarski and Hirsch's study, the pre and the posttest were dissimilar. No analysis can be made against the 2 test because the content tested was different. There should have been a pre and posttest for the following areas of concern: (a) the mathematical prior knowledge assessment, (b) the mathematical reasoning, and (c) the meta-cognitive knowledge assessment. The pre and post assessments would have given some information about the starting point of each group. This study only compared the groups to each other after the treatment.

In the final research analysis, based on teaching strategies, a variation of R. L. Moore's Discover Method was used to teach abstract algebra to a class of mathematical education majors at a small liberal arts college. R. L. Moore, a University of Texas mathematician, discovered a method that required a class of mathematics students to prove all theorems entirely by themselves. The results would be a profound knowledge base that could be retained and used for future mathematical courses.

The use of R. L. Moore's Discover Method allowed students to discover as much as they possibly could by themselves before they were allowed to integrate technology to facilitate their discovery. "In almost every case students initially had expressed some hostility to the idea of active discovery-oriented learning" (Perry, 2004). The students' resistance could be traced to their past experiences with the traditional method of learning in the math classroom.

By the end of the course the majority of the students were thinking independently and they appreciated the empowerment given by the discovery method. This discovery course, compared to the lecture-oriented course, helped the students gain abstract thinking skills that could be used in advance mathematical classes.

This study by Perry (2004), did not include the following: (a) a research method, (b) a method of selecting the participants, (c) a method of collecting or analyzing data, and (d) an analysis of pre and post data.

During all 3 of these studies, a specific teaching strategy was used with the computer based technology in an Algebra setting. None of the results focused on improving test scores or using the technology as a motivating factor that would improve test scores.

Giving students control. One research study focused on using computer based technology as a method that would heighten students control over the learning environment and increased their interest and engagement in a mathematical classroom. This study was an exploratory study that was performed using students in an eighth grade mathematical classroom with a computer learning system called Destination Math (DM). "Destination Math (DM) is a comprehensive simulation based math program, designed to supplement or replace traditional math curricula, by focusing on the development of students' problem solving and analytical skills" (FitzPatrick, 2001, p. 109). DM was implemented using two eighth grade math classes, in a rural mid-Atlantic Junior-Senior

High School, for a complete semester. The main research question asked was: "how do students experience a classroom innovation in the form of an interactive learning system in their math class, during a semester-long implementation process" (FitzPatrick, 2001, p. 108).

The participants in this study consisted of 32 students taken from two lower-level eighth grade math classes. One class consisted of 14 students while the other class consisted of 18 students. The 10 week long study consisted of 4 modules: (a) a fractions module, (b) a decimal module, (c) a percent module, and (d) an integer module. Each module was broken down into 3 units: (a) a tutorial unit, (b) a workout unit – with practice problems, and (c) a teacher assigned test unit.

Data was collected using various methods: (a) field notes were used to record pre and post instruction, (b) semi-structured interviews were used with focus groups during the implementation of the lesson, and (c) documentation was used to summarize the data (FitzPatrick, 2001, p. 107).

The students concluded that DM increased their interest, engagement, and productivity with math for the following reasons: (a) they had control over their choice of activity, (b) the math content used multiple representations, and (c) there were opportunities for peer collaboration.

This study by FitzPatrick (2001) recorded and observed students' experiences in an interactive computerized environment. This research was important because it did record positive student responses in an interactive computerized environment that could reveal the presence of motivated individuals. This study did not show any relationship between test scores because that was not the focus. The method of selecting the participants was not mention and that method could have played an important part in the data results. No evidence supporting students' low performance was documented or tested. No pre-analysis of the students' previous feeling about the prior math environment was performed. No control group was used as a comparison group to validate the data.

Algebra Remediation. In the next 2 research studies, a comparative analysis was used with computer based technology to remediate Algebra knowledge. The first study was a comparative analysis between students using an online system and students using the traditional method of learning. The second study was a comparative analysis between 2 online interactive computer systems.

In the first analysis an online mathematical system, called "Math Online," engaged the students in active learning of mathematics. This online system reinforced basic algebraic and calculus skills by randomly generating multiple-choice questions. The goal of this online system was to move the prerequisite skills for calculus out of the classroom, which would free the classroom time for activities related to calculus. Math Online would also allow the students to get the practice that they needed with immediate feedback.

A background analysis of "Math Online" indicated that this software program was created by the Mathematics Faculty at Fairfield University as a web based interactive system that would generate multiple-choice questions for the purpose of reinforcing and providing practice for algebraic and calculus skills (McSweeney & Weiss, 2003, p. 348). The lineament of "Math Online" consisted of instructor-constructed quizzes and assignments, information about the student's performance, and an online grade book with secure student access (McSweeney & Weiss, 2003, p. 348).

This study lasted 4 consecutive semesters, from fall semester 2000 to spring semester 2002. There were 7 instructors that participated in the fall semester of 2000 with 6 of those fall instructors participating in the spring semester of 2001. In fall 2001, 5 instructors participated and 4 of those instructors from the fall participated in the spring 2002 semester.

Each instructor had two sections of an Applied Calculus class consisting of about 25 to 35 students. One of the two sections of Applied Calculus was randomly assigned to utilize the Math online course, while the other section just received teacher taught assignments and assessment like in a traditional classroom (McSweeney & Weiss, 2003, p. 350). The data collection process consisted of using 2 sets of instruments: (a) a 15 multiple-choice question pre-test and post-test on algebra and pre-calculus content given before and at the end of the fall semester and (b) a semester and final exam containing 24 common calculus questions the first year and 14 common calculus questions the second year. The common calculus questions were not multiple choice questions but questions where the students answered by writing out their solutions. The scoring of the calculus questions were based on a predetermined rubric. The overall results proved that the "Math Online" sections had a higher average than the control sections during both academic years.

McSweeney and Weiss used the "Math Online" system as a means of remediation for their college calculus classes. My participants were first year high school 9th graders taking an Algebra class. The participants were placed in groups called the treatment group and the control group. College level students are self-motivated to improve their grades, for personal or monetary reasons, and will complete the work necessary to pass their class.

In the second research study, another comparative analysis was performed between 2 different types of online interactive systems. This analysis investigated which online interactive system would help students master the concepts taught in a textbook and lecture based class. The ALEKS (Assessment and LEarning in Knowledge and Space) and the MathXL were the 2 interactive online programs used by the students for 2 consecutive years. Two research questions guided this study: (a) How do students respond to various learning experiences and tutorials including text interactive online support, and (b) How did students' performance reflect the learning achieved with classroom lectures and required work on an online interactive system (Stillson & Nag, 2009, p. 241).

During the fall of 2005, the online Basic Algebra program selected 118 participants to use the ALEKS online interactive system, and during the fall of 2006, 92 participants were selected to use the MathXL online interactive system. The participants were given some basic knowledge of algebraic concepts and problem solving strategies that were demonstrated by using tables, data, graphs, and an online interactive CAS. The online interactive CAS main purpose was to implement the resolution of simply and complex problems without the use of calculators (Stillson & Nag, 2009, p. 241). In-class and online quizzes were given plus homework was collected that required proper algebraic steps for full credit.

The analysis based on the first research question was conducted by using 2 questions from an end-of-semester survey. The largest percent of improvement came from the students understanding of the concepts of Algebra by lectures and personal practices. In the fall of 2005, 82.4% agreed that lecture and personal practice helped them with the math concepts while 90.7% in the fall of 2006 believed that lecture and personal practice helped them with the math concepts. The analysis based on the second research question was conducted by making a comparison between 3 in-class written examinations, 2 unit exams and 1 final exam.

The results of this study, as it related to the second research question by Stillson and Nag, indicated an improvement with the average and median scores on the unit exams and the final exams from the fall 2005 term to the fall 2006 term. The final exam scores of this group for both semesters indicated that 50% of the students met or exceeded the 70% passing score (Stillson & Nag, 2009, p. 244).

The overall conclusion is that there is no sufficient evidence to support the claim that the combined effect of online software MathXL and lecture was better for the students compared to the ALEKS and lecture. Although there was no significant improvement in the test scores between the 2 online software systems, there were several procedures that could have caused these results. One process dealt with the fact that students were allowed to re-take test up to 15 times using the same types of problems on each test. Only the highest score would be recorded. This process makes comparing of test scores invalid. The survey instrument only had two questions. This made the survey instrument unreliable.

The 2 comparative studies both tested an online computer based algebra system. The first study proved successful comparing a computer based system to the traditional method of teaching while the second study proved that there is no significant improvement between 2 online systems.

Comparing a traditional method. In the last study under computer based technology in an Algebra classroom, a comparative analysis between a Computer Algebra System (CAS), and the traditional paper and pencil approach is examined. The purpose of this study was to investigate which approach, CAS or paper and pencil, would help students obtain and retain procedural knowledge while learning the concept of completing the squares. Procedural knowledge refers to the steps or actions sequences used when solving algebraic problems. The procedural knowledge approach has been identified as one of the traditional methods in learning algebra that can be successfully manipulated using a CAS which will save time and give more time for conceptual understanding of concepts (Abdullah , 2007, p. 18).

The setting of this study took place in a secondary school on the east coast of Malaysia. The participants were 164 students using 30 workstations (with CAS software), in a multimedia laboratory with one workstation for teachers, a liquid crystal display (LCD) projector, a screen and a white board. The students were given a Mathematical notebook, an activity notebook, and a paper study guide booklet to record any information that helped them in their discovery. The students' discovery sessions lasted

40 minutes for each session of Algebra using the CAS and the same lesson using a traditional procedural knowledge approach.

After completing the lessons, the students were asked to respond to a survey that contained10 items. The data was collected and processed using only 4 items from the survey. The data was then analyzed using a “fuzzy” evaluation method. “The fuzzy evaluation method recognizes the subjectivity of the following words: agree, disagree, time-consuming, difficult, and easy by giving variations for each category” (Abdullah, 2007, p. 16).

The results of this survey showed that the students strongly agreed and supported the manipulation of CAS in helping them to acquire procedural knowledge in the Algebraic classroom.

Although this study used a computer algebra system in an algebra classroom, the qualitative results investigated how students rated the comparison of using the paper and pencil approach against the CAS approach for gaining procedural knowledge. The procedural knowledge was not pre-tested or pro-tested to actually measure any increases due to the use of a CAS.

Calculator Based Research as a Computer Algebra System

In this section on calculator based research as a CAS, there were 8 research studies that focused on calculator based technology as a Computer Algebra System (CAS) in the mathematical classroom. The synthesis of these calculator based research studies formed 2 areas of significance: (a), the effects of using calculators as a tool to enhance teaching and learning in the mathematical classroom and (b) the effects of using calculators to increase students' performance on exams and assessments in the mathematical classroom.

Teaching and learning. In this section, 5 research analyses focused on using a specific teaching strategy with the graphing calculator as a Computer Algebra System (CAS) to help students learn and understand Algebra. In the first study, non-routine problems were used with the TI-92 calculator. In the second study the teacher modeling the use of the calculator was compared to the students' use of the calculator. In the third and fourth analysis the calculator was used as a visual tool to help with the understanding of Algebra concepts. In the final analysis, the calculator was used with special software that monitored the students' calculator key strokes.

In the first study, the effects of using the calculator with non-routine problems were examined by 2 researchers. Grassl and Mingus (2002) supported the belief that "students at all levels needed exposure to non-routine problems that illustrate the effective use of technology in their resolution" (p. 715). Exposure to non-routing problems and the use of the TI-92 or the TI-89 would produce a type of cognitive technology mode that according to Grassl and Mingus (2002) "would transcend the limitations of the mind in thinking, learning, and problem solving" (p. 714). The students would then become able to produce sound conjectures about mathematical proofs.

In order for the students and teachers to benefit from the use of technology, students must be proficient in the use of the TI-92 and the teachers must select appropriate problems that would entice the students in a cognitive manner.

“In this study the TI-92 served as a cognitive amplifier by prompting students to re-examine their desires and ability to construct valid mathematical proofs” (Grassl, 2002). Cognitive type problems would challenge the discovery process in the students. It would also give the students the opportunity to use their own techniques with no limitations on generalizations and connections.

Grassl and Mingus surveyed 35 students at the conclusion of a sophomore-level discrete mathematics class that encountered non-routine discovery questions while using the TI-92. The results of this survey revealed that 31 out of 35 students claimed that the TI-92 was helped them to understand and complete the math assignments in the math workbook (Grassl & Mingus, 2002, p. 722).

This survey showed the opinions of the students but no data was presented that validated the students’ conclusions. No historical data was presented to establish the students’ existing feelings or existing level of performance before the survey. Grassl and Mingus used convenient sampling method but selected only a few students to survey. In the second analysis, the teacher’s expectations for calculator usage were investigated to examine whether the students’ behavior reciprocated that expectation. The teacher had to first write down the goals he or she wanted to students to follow, then through observation and monitoring software these goals were investigated (Graham, Headlam, Sharp, Watson, 2008, p. 182).

This study consisted of 2 stages. The first stage took place over a two week period, where key-recording software, in the teacher’s calculator, was installed to log every keystroke that was made by the teacher. In the second stage, the students were assigned to this study, based on their exposure to the graphical calculator. In stage one, the key-recording software helped to facilitate the transfer of keystroke information and images of the calculator screen onto videotapes. The videotapes were then analyzed by the research time. The research team also analyzed any written observational tool and they consulted with the teacher to make sure that the goals of the teacher and the results from the students were exactly aligned (Graham et al., 2008, p. 183). The following is a list of the teacher's goals and expectations while teaching the students' how to use the graphical calculators: (a) making the students confident users of the graphical calculators, (b) giving the students the calculator knowledge needed to successfully complete and understand the mathematical concepts (c) giving the students the "short cut" methods needed on "timed" exams, (d) making the students aware of the visual display qualities of the graphical calculator, (e) making the students aware of the investigative abilities of the graphical calculators when introducing new mathematical topics, and finally (f) making the students aware of the graphical calculator as a tool for self-checking of their solutions (Graham et al., 2008, p. 186).

In the second stage, after the analysis of the teacher's expectations or goals for the students, the participants were selected from a group with the greatest exposure to the graphical calculator. The participants consisted of 5 year-12 students studying A-level mathematics. After the teacher taught 4 lessons in advanced mathematics, the students were given by the research team a questionnaire that assess how well the teacher's goals had been taught to them (Graham et al, 2008, p.187). Next, the participants were given this semi-structured individualized interview that was tape recorded, transcribed and summarized to see if the students' use of the calculator matched the teacher's goals for using the graphical calculator.

The results of this study proved that all of the teacher's goals or expectations were met to some extent by the majority of the students. However, this study lacked the randomization needed to make any generalization to my study. Its selection process has significance only to the 5 students in the study. I improved on this study because I had a broader sample size and I used a quasi-experimental research design that gave a quantitative perspective about technology and student achievement on assessment test.

The third analysis focused on a doctoral thesis that analyzed the effects of using graphical calculators to visualize Algebraic concepts. The purpose of using the graphical calculators for visualization of Algebra concepts is that it would free the students from carrying out operations by hand and it would direct their attention toward concept development and problem-solving strategies.

The understanding of algebraic concepts and operations were manipulated by using a computer algebra system (CAS) called the TI-89. The specific area of Algebraic focus was the concept of parameter. "A design research methodology was used, which is also known as developmental research, aimed to develop theories and an empirically grounded understanding of how learning works" (Drijvers, 2004, p. 81). Drijvers explored one major research question that was related to the use of CAS to promote algebraic understanding of concepts and operations. Using that one research questions, 2 sub-research questions were analyzed: (a) can a CAS encourage higher levels of understanding of the concepts of parameters, and (b) is there a relationship between the techniques used in the CAS environment and the actual acquisition of algebraic concepts (Drijvers, 2004, p. 77).

There were 3 main research cycles: G9-I that stands for 9th grade first cohort, G9-II that stands for 9th grade second cohort, G10-II that stands for 10th grade second cohort, and 1 intermediate cycle called G10-I that stands for 10th grade first cohort.

The first and second research cycles lasted for 5 weeks and consisted of 4 lessons each week while the third cycle contained only 15 lessons and the intermediate cycle contained 5 lessons. Each cycle consisted of 3 phases: a preliminary phase – this phase was where the research hypothesis was developed, (b) the teaching experiment phase – this phase was the gathering of the data collection instructions used in the discovery process, and (c) the retrospective analysis – where data is selected, coded, and analyzed. Over 100 lessons were given to 110 students. Data was collected by 2 observers who observed and videotaped students' behavior, recorded information from mini-interviews with the students, and gathered notes from the students' written document.

The conclusion based on the first research sub-question proved that the use of a CAS system can improve students understanding of algebraic operations and concepts In fact, the students achieved a higher level of understanding of the algebraic concept of parameter (Drijvers, 2004, p. 83). The conclusion based on the second research sub-question proved that there is little or no relationship between the instrumentation techniques in the computer algebra environment and mathematical conceptual knowledge. There was instrumentation difficulties that hindered the students' learning which made the students depend more on the support from the teacher (Drijvers, 2004, p. 85).

Drijvers' major research questions and sub-questions were unrelated to each other. Success with testing 1 concept in algebra cannot be generalized to the success of all concepts or operations in algebra. The analysis of the data does not mention comparison of test scores from pre or posttest to show any effects from the use of the TI-89. There was a small possibility that there might be a relationship between interactive technology and test scores but none was mentioned by Drijvers. Drijvers, however, made the following recommendations for teaching algebra students using a CAS: (a) plan in advance the different and possible uses of a CAS, (b) make changes when necessary but remember to be concise, (c) provide individual and group tutoring on using the CAS, (d) have student complete a comparison analysis between their CAS techniques and the paper-and-pencil techniques, and the final recommendation would be (e) students reflection on their experiences and uses of a CAS (Drijvers, 2004, p. 87). Once again, no relationship is shown between motivation, test scores, and interactive technology.

The fourth analysis examined the effects on learning when teachers provide learning experiences with calculator knowledge during instruction. This analysis was a case study that explored the students' understanding of how graphing calculators are used to find a global view of the graphical representation of a difficult function. Brown (2004) quoted Anderson, Bloom, Mueller, & Pedler (1999) by stating the following, "with the mandating of graphical calculators use in schools, expertise in using a graphing calculator to find a global view of the graphical representation has become essential for senior secondary mathematic students studying functions" (p. 6). The expertise needed to effectively use the graphical features of the calculator can only be achieved through experiences that develop the students understanding of the various output features of the calculator including the effects of changing the scales and the shape of the graph (Brown, 2004, p. 10).

The participants in this study were selected from mathematical classrooms where the students were expected to use the graphing calculator intelligently to solve problems. The participants consisted of 10 students grouped in 5 pairs; 2 pairs from a year 12 mathematical classroom and 3 pairs from a year 11 mathematical classroom. The 5 pairs of students were organized into cooperative groups and asked to produce a sketch of the completed graph of a difficult cubic function and to record the mathematical and graphical knowledge needed while performing that task to a resolution stage. The students' strategies were being observed, not their solutions or their success rate

All the pairs of students eventually solved the task. One pair from the year 12 mathematical class was able to synthesize their mathematical and graphical calculator knowledge to form a solution process that quickly enabled them to complete the task. Brown (2004) concluded his study with the following statement about the results: "this study supported the view that the combined application of mathematical and graphical calculator knowledge is more efficient and effective in the determination of a global view of a difficult function" (p. 8).

Although this study supported the use of interactive technology to support students mathematical knowledge about the graph of difficult functions, this study did not utilize a control group as a comparison to the treatment. The purpose of this case study was not to compare statistical data on the students' success at completing a task, but this case study purpose was to observe and record the student's strategies at a mathematical task. The sample size was not a valid size to make any generalized conclusions for the use of graphing calculator knowledge to improve students understanding of the graph or image of a difficult function.

This study can only make conclusions based on the students in that study and not to the general population for the following reasons: (a) no statistics was conducted to test pre and post knowledge of the students, (b) the classes were conveniently selected and no control group was used, and (c) this study was conducted with college level students, who had some previous college mathematical classes.

In the final research analysis about the effects of using calculators as a tool to enhance teaching and learning in the mathematical classroom, the TI-83 Plus calculator was used with special software that would record the students' calculator keystrokes. Observing the students' keystrokes would give insight into their problem solving strategies. Knowledge of the student's keystrokes is knowledge of their working style, knowledge of their understanding of the mathematical concepts, and knowledge of their thinking process (Berry, Graham, & Smith, 2006, p. 291). There were 4 questions in this study by Berry et al. that played a major role in my study: (a) what would be the student's working style while using new technology, (b) would the students' working style change when compared to the traditional method of using paper and pencil, (c) would the students adopt their own working style or would they mimic the working style of the teacher, and finally (d) what conclusions could be drawn from this study that would be based on the students' understanding of mathematics (Berry et al., 2006, p. 292).

There were 3 pilot studies conducted using key-recorder software that would record the students' key strokes during calculator problem solving. The participants in the first pilot study were 11 year olds that made 1 test group consisting of 14 students. The participants in the second pilot study were "A-level[j]" mathematics students studying statistics. The participants in the third pilot study were undergraduate mathematics students taking their first year mathematics course.

The first pilot group's working style can be described as an experimental trial or an improvement approach when using the calculator. This process is traditionally called the "trial and error" method. The second pilot group rarely used the calculator. This had a negative effect on their examination score. Berry et al. (2006) made the following conclusion about the second pilot study: "there need to be ways of promoting the use of the graphical calculator if the students are to gain the full benefit of having it as an aid to their studies" (p.302). The third and final pilot group used the calculator as a "key punching" exercise. In other words, they showed little knowledge of what they were doing and how they could get the correct answer. They relied on the calculator as a tool that would always give them the right answers, which turned out to be the wrong answer.

Berry et al., (2006) concluded the study with the following inferences about observing and recording students' working style with graphical calculators:

Students' strategies can be identified,

[j] A-Level stands for advanced level. An A-Level mathematical is an advanced level class.

The level and type of the use of calculators can be monitored.
And key-recording software can provide details of the misuse or over-reliance on technology (p. 306).

The participants in the pilot groups were dissimilar and no comparison could be made between the groups. Their different working strategies could have been related to their age and experience with mathematics. The sample size was also too small for any generalization. The relevance of this research to my study is that this study identified the importance of monitoring the students and correcting or modifying their working style. The insight into the students' algebraic thinking process during mathematical problem solving can be defined by their keystrokes on the calculator and their results on examinations and assessments.

Students' performance on assessments. The use of calculator based research to improve students' performance on assessment test was the focus of the next 3 research studies. The first study examined the effects of using calculators on a statistics exam, the second study examined the effects of using calculators during a discrete mathematical exam and the third study was a comparative analysis between students using the calculator on exams and students not using the calculator on exams.

The first analysis investigated whether the use of graphical calculator developed mathematical understanding and whether that mathematical understanding translated into higher test scores on assessments. Graham, Headlam, Honey, Sharp, and Smith (2003) researched prior studies and found that using calculators when testing almost consistently translated into positive results on assessments related to computational and problem-solving skills (p. 219).

This study selected a small group of students from an A-level mathematical class that were halfway through the second year and on the third module in a statistics course. The participants were 7 students between the ages of 17 and 18 years, who were halfway through the second year of an Advanced Level Mathematics course and who had owned a graphical calculator since the beginning of the course.

This study was conducted in 3 parts: (a) the expert analysis part – this is the part where the researchers actually took the examination so that they could identify all opportunities where the graphical calculator could be used, (b) the recording part – this is the part where special software was installed in the calculators that would capture the keystrokes during the exam. The keystrokes where then saved within each calculators' internal memory, and (c) the interviews part – this is the part that was the follow-up interviews were held with all the participants (Graham et al., 2003, p. 322).

The researchers categorized 3 ways that the graphing calculator could be used by the students during examination: (a) the quasi-scientific method – used to represent the student not using the graphical calculator but using the scientific calculator instead, (b) the semi-proficient method – used to represent the students manipulating only some of the features of the graphical calculator, and (c) the proficient method – used to represent the students manipulating all of the features of the graphical calculator to obtain the most efficient solution (Graham et al., 2003, p. 323).

During the actual study, the participants were given a TI83 plus graphical calculator and a scientific calculator to be used on a mock examination that covered the third module in statistics. The results of the study showed that the students used the scientific calculator more and rarely used the TI 83 Plus graphical calculator. During the interview process several reasons emerged that explained why the students may have used the TI 83 Plus graphical calculators less than the scientific calculators: (a) the students were more familiar with using the scientific calculators than they were using the graphical calculators – the students used the scientific calculators for about 6 years while they only used the graphical calculators for about 18 months, (b) during previous exams, the graphical calculators were prohibited, because the exams were mostly based on using the scientific calculators, (c) the exams were written that focused more on the use of tables and not graphical calculators, and (d) the exam was marked or graded based on the students written knowledge of solving a problems – using the graphical calculators would not allow the students to show their concepts or strategies during problem solving (Graham et al., 2003, p. 233).

This study only investigated how students used the TI 83 plus graphical calculator. This study did not perform a data analysis of the results of the student's mathematical knowledge before or after the use of the TI83 plus graphical calculator. The study group size and the selection method prohibit any generalization of the results.

In the second study, an investigation on the impact of a Computer Algebra System (CAS) on student achievement was analyzed in a classroom studying discrete mathematics. This study investigated any significant differences and similarities of students' achievement and students' approach to problem solving. Two cohorts were analyzed: (a) students using the TI-92, and (b) a control section of students not using the TI-92. A quantitative method was used to examine any significant differences and similarities in the test scores of the students while a qualitative method was used to categorize the various approaches students used when solving problems.

The location of this study was a moderately sized university in the Western United States. The participants were 61 students (31 females and 30 males) that were randomly assigned to each cohort. During a semester long study, the treatment group used a TI-92 with an interactive workbook. This interactive workbook allowed the participants to explore data collection, conjecture and discover counterexamples. "In the control group, the instructor neither promoted nor discouraged the use of calculators, but allowed the students who owned calculators to use them without providing them direction on calculator usage" (Powers, Allison, & Grassl, 2005, p. 104). The workbook assignments for both groups were the same. The instructors administered 3 in-class mid-term examinations and 1 cumulative in-class final examination that were used to compute the correlation between the items and used to test the inter-rater reliability (Powers et al., 2005, p. 105).

The results of this study on assessment performance, proved little or no significant differences between the CAS group and the control group on each of the in-class examinations, and the final examination. The results of this study on students' various approaches used in solving typical problems associated with discrete mathematics suggested the following: "(a) the use of a CAS in discrete mathematics may help increase problem-solving approaches and (b) with the availability of the CAS as a tool, students in the CAS group did not replace pencil and paper techniques with the calculator" (Powers et al, 2005, p. 110).

This study has 3 areas of relevance to my study: (a) the use of CAS with a treatment group, and no emphasis of CAS with the control group, (b) the research methodologies are similar, and (c) the data collection and analysis methods both used the t-tests as the inferential statistics. This study used randomization for the sample and I used convenient sampling. The sample group was college level students while my sample group was students of various ages in an Algebra 1 class. I improved on this study by offering students a variety of 21st century computer based systems like the TI Nspire calculators, e-instruction clickers, and the TI navigator.

In the third study, a comparative analysis was conducted in Germany between the years of 2000 and 2004. This comparative analysis investigated the mathematical performance between students in grade 11 using a computer algebra system (CAS) and students not using a computer algebra system. "This study attempted to examine whether and how the use of CAS effected students' performance and which mathematical fields benefited most from using CAS" (Schmidt, Kohler, & Moldenhauer, 2008, p. 11).

During the selection process, 8 out of 107 schools were selected and 1949 students participated. There were 805 non-CAS participants and 1144 CAS participants divided into 2 cohorts, which were sub-grouped into 3 levels according to their academic plan or course plan. The 3 sub-groups related to the student's academic plan were: (a) the basic course – these were students that selected 8 basic courses and 2 advanced courses,

(b) the advanced course plan represented students that took more than 2 advance courses, had 50% more instructional lessons per week, and was required to take a final exam, and (c) the students in a specially designed class were exemplary students with exceptional mathematical talent (Schmidt et al., 2008, p. 12).

The students were given a TI-89 in grade 10 to use, which allowed them one full year of computer experience. Three months after each student entered the eleventh grade, an assessment was given. This process continued every year, for students in the eleventh grade, for 5 consecutive years. Only one assessment, containing 26 questions, was given to the students. The 26 questions were categorized into 5 areas of mathematical competence: (a) simplifying expressions (arithmetic), (b) solving equations and inequalities, (c) Geometry, (d) functions and graphs, and (e) probability. The results from the test were weighted by the number of students before analysis. The 2004 data was collected and compared for that year, and then a comparison was made to the prior years. The November 2004 data analysis yielded the following results: (a) the students labeled as exemplary outperformed all of the other students, (b) the students using the computer algebra system in the basic and advanced courses outperform all other students on exams, (c)the students in the basic courses using a computer algebra system scored 11% higher than the students in the basic group not using a computer algebra system, (d) the scores of the advanced students using a computer algebra system scored 19% higher than the students in the advanced group not using the computer algebra system, and (e) the exemplary students using a computer algebra system scored 10% less than the non-CAS students in the same courses (Schmidt et al., 2008, p. 14).

The results of comparing the performance in different mathematical fields concluded that on average the CAS students outperformed the non-CAS students. Overall the CAS students solved 23 questions better than the non-CAS students while the non-CAS students solved 3 questions better than the CAS students.

Comparing the total results of CAS students and non-CAS students over a period of 5 consecutive years proved that the CAS students outperformed the non-CAS students. The authors concluded the following about using CAS in a mathematical classroom: “CAS enhances students” performance within each of the 5 considered mathematical competence during the years 2002 to 2004. However, the field with the highest performance enhancement changed from year to year (Schmidt et al., 2008, p. 14).

The Schmidt et al. research study used a convenient sampling method of selecting the participants, which was similar to my study. The treatment group/control group method was used to check the effects of a CAS system. Schmidt et al. did not perform any type of pretest or pre-test/post-test comparison of the student test scores. The study only compared results after the treatment between groups.

Computers used with Calculators as a Computer Algebra System

In the final section based on Technological Research in Mathematics, the final research study focused on using the computer and the calculator simultaneously as a Computer Algebra System (CAS). The students in this study used the calculator, a computer with Internet access, a view screen that was used to project the calculator, and a data projector.

The purpose of this study was to investigate the use of technology for teaching and learning, by assessing how computers and the calculator supported mathematical learning. The learning competences for this study focused on the following: (a) the knowledge-building value of computer based activities and (b) the technical understanding that is necessary for successful mathematical learning. The knowledge building value of computer based activities allowed the users to graph functions, transform functions, calculate function and generate relationship representation between functions (Forster, 2006, p. 147).

The setting of this study was an all-girls' private school in Western Australia, with 22 senior, in an "Applicable Mathematics" course, studying descriptive statistics. Applicable Mathematics is a tertiary entrance examination (TEE) course that mandates the use of a graphical calculator (Forster, 2006, p. 150). The students owned and used a Hewlett Packard HP39G graphical calculator. The students also had at least one year of calculator experience prior to this study. The classroom was equipped with an internet connected lap-top, a data projector, and a view screen for use with the graphical calculator.

The data collection process was based on 17 consecutive lessons where the following was collected: (a) field notes from classroom discussions and observations of student learning, (b) video-recording of lessons, (c) assessment tasks and students' assessment scripts photocopied, (d) notes of informal interviews with students while they worked, and (e) notes during interviews with the teacher after lessons and during the initial analysis of the data.

In the concluding discussion, the author observed the following concerning mathematical learning: "(a) direct manipulation of the graphs was possible, (b) the graphs were linked to other representations and the linked representations could be viewed simultaneously, and (c) the graphs included visual clues which pointed to the inference that was intended" (Forster, 2006, p. 159). "Technical understanding was observed by the students' using routine steps during basic computations, defining mathematical basis of commands and syntax, and defining actions to assist them in their interpretation of graphs" (Forster, 2006, p. 160). There was also a socio-cultural context that defined or influenced technology-based teaching and learning in this study. At the school level the decision to provide projection technology, and a laptop with internet connection was influential in this study. At the school district level the mandate to use the graphic calculator and the style of questions in the Applicable Mathematics tertiary entrance examinations (TEE) also influenced or facilitated this study.

This study did not record or compare any pre-test data or statistics. No control group was utilized. The content area of research was statistics while my area of research was algebra 1.

Summary

Each section in this literature review has validated the purpose of this study. In section 1, the significance of this study could impact the entire future of our national existence. In section 2, the social impact of this study could affect society by changing the way children are educated in the 21st century and by using technology as a tool to reduce and close the digital divide. In section 3, motivation is viewed by the research as a key factor that would initially engage the students. And finally in section 4, the research explored various parts of my study, but none of the research focused on the current technology available to the youth today. Today, students or 21st century students need 21st century technology that will challenge and motivate them to improve significantly on local and national assessment test.

Chapter 3: Research Methodology

Introduction

This study analyzed and synthesized the effects of students' motivation in the classroom before and after the use of interactive technology by analyzing their test results and the results from a motivational survey. A quantitative method using a quasi-experimental design measured numerically the level of the students' motivation and the effects of motivation on academic performance. This quantitative quasi-experimental design gave me the ability to provide a broader perspective of the use of interactive technology on test scores and revealed statistically any comparisons or correlations in the data between motivation, test scores, and interactive technology. "A quantitative study according to Reaves (1992) does not deny or ignore personal experiences. It merely insists that these experiences be quantified, measured on some scale, before they can be scientifically studied" (p.16).

Mitchell and Jolley (1988) quoted Cook and Campbell (1979) with the following statement about quasi-experimental designs, "quasi-experiments are experiments that have treatments, outcome measures, and experimental units, but do not use random assignment to create the comparisons from which treatment caused change is inferred" (p. 242). Cook and Campbell (1979) further states that "although random assignments create the comparisons from which treatment-caused change is inferred, quasi-experiments creates it's comparisons on nonequivalent groups that differ from each other in many ways other than the presence of a treatment whose effects are being tested" (p.6).

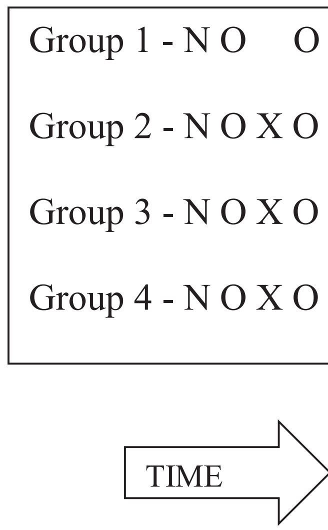
This quasi-experiment consisted of nonequivalent groups. Nonequivalent control group design according to Caporaso (1973) "is extremely useful in judging the effects of a variable on a group where that group has assembled naturally (i.e., has not been brought together by the experimenter for his own purposes" (p. 12).

The non-random assigned groups was selected conveniently. The groups receiving the treatment of technology was called the treatment groups, or group B_1 and B_2, while the groups not receiving the treatment of technology was called the control, or group A_1 and A_2. All groups received both a pretest and posttest survey. A multivariate analysis of variance was used during the data analysis process because "it is the statistical test used to assess the significance of the effect of one or more independent variables on a set of two or more dependent variables" (Grimm & Yarnold, 1995, p. 245).

Design Methodology

The quantitative quasi-experiment design that was used in this study is called nonequivalent-groups design (NEGD, see Figure 1). Campbell and Stanley (1963) said that "one of the most widespread experimental designs in educational research involves an experimental group and a control group both given a pretest and a posttest, but in which the control group and the experimental group does not have pre-experimental sampling equivalence" (p.47).

Quasi-Experimental Design
The Nonequivalent-Group Design
Notation for the Nonequivalent-Groups Design (NEGD)



Pre-Test and Post-test was given at the same time for each group

“X” indicates the treatment

“N” indicates the groups are non- randomly assigned

“O” indicates observation or measures

Each line represents one group

Figure 1 Quasi-experimental design

This quasi-experiment design is equivalent to an experimental design, except it lacks the random assignment. Experimental research according to Johnson and Christensen (2008) provides the strongest evidence of all the research methods about the existence of cause-and-effect relationships because it actively manipulates the dependent variables" (p.41). I utilized four groups of participants: (a) Group 1 was called the control group and (b) Groups 2 through 4 were called the treatment groups. All groups received a pre and posttest. The pretest and posttest were exactly the same for the Motivational Strategy for Learning Questionnaire (MSLQ) but the STAAR was a district provided benchmark test for the pretest and the actual STAAR state test for the posttest. The groups associated with this design were eight, comparable classrooms where students had already been assigned. Justification of this method is given by Boaler (2008) in the following statement:

> Researchers in mathematics education conduct quasi-experiments to compare the effect of teaching approaches, not by assigning students to random or equated groups but by following students in groups formed by their schools and using statistical methods to control for prior achievement. (p. 590)

Setting and Sample

The Setting

This study took place during the regular class periods between the hours of 8:50 and 4:22. The assessment test was given during the actual school hours, as a school wide benchmark test. Two math teachers, teacher A and teacher B, taught their classes using various technologies. Each teacher had 4 classes of students. The first class used no technology, the second class used just the IT Nspires calculators, the third class used the TI Nspire with navigational features, and the fourth class used TI Nspire with navigational features and E-Instruction clickers. All the students were conveniently selected and existed as the present students in the teachers' classes.

The Sample

The sample consisted of students of various ages and various levels of math competence. There were approximately 20 students in eight Algebra 1 classrooms. These students were randomly placed in the classrooms by the scheduling team at the beginning of the school year. My sample consisted of these students because they were already placed in these classrooms. This made my sample a convenience sample, where the students were unevenly and arbitrarily distributed. The classes from each teacher were combined into four groups; Group 1 (the control group), Group 2 (used the TI Nspires only), Group 3 (used the TI Nspires with the TI navigator), Group 4 (used the TI Nspires, the TI navigator, and e-Instruction clickers). Groups 2, 3, and 4 were called the treatment groups.

Instrumentation and Materials

The participants completed a pre and post motivational questionnaire (MSLQ) and a Pre-STAAR and the actual STAAR test as the post test. The students wrote their answers to the motivational questionnaire on the questionnaire and the STAAR test answers were recorded on a scantron that was provided. The following instruments were used to record data: (a) questionnaire summary documents, and (b) scantrons (for recording test scores).

Motivational Questionnaire

Self-report questionnaires, specifically motivational questionnaires, are one of the most commonly used research instruments because motivation is not easily observable (Huang, 2008, p. 529). The motivational questionnaire used in this study was the Motivated Strategies for Learning Questionnaire (MSLQ), which is an existing instrument (see Appendix B, Assessment #1).

The MSLQ was originally used to assess college students' motivational orientations and their use of different learning strategies. It contained 31 motivational questions and 50 questions that test student's different learning strategies. Only the section on motivation, 30 questions, was used. "The motivational section contains three parts: (a) the value component questions, (b) the expectancy component questions, and (c) the affective component questions" (Pintrich & Others, 1991).

The value component of the MSLQ measured intrinsic goals, extrinsic goals, and the value of the task that is performed. The Intrinsic Goal section referred to the student's perception of the inherent reasons why he or she was engaged in a learning task. Some internal or inherent reasons might include personal challenge, curiosity, or mastery of the learning task (items: 1, 16, 22, and 24). The Extrinsic Goal section referred to the student's perception of the external reasons why he or she was engaged in a learning task. Some external reasons could be for grades, rewards, performance, evaluations by others, or competition (items: 7, 11, 13, and 30). The Task Value referred to the measurement of the student's perception of how interesting, how important, and how useful the task was to him or her (items: 4, 10, 17, 23, 26, and 27).

The expectancy component measured the student's perception of their expected outcome of the learning: expectancy for success and expectancy for self-efficacy. One Expectancy Component is the Control of Learning beliefs. This referred to the student's perception that their efforts to learn would result in positive outcomes (items: 2, 9, 18, and 25). Expectancy Component of Self-Efficacy for Learning and Performance referred to the student's perception that the learning would lead to success and self-efficacy (items: 5, 6, 12, 15, 20, 21, 29, and 31) (Pintrich & Others, 1991, pp. 9-13). Finally the affective component measured the student's test anxiety (items: 3, 8, 14, 19 and 28).

Assessment Test

In 1999 the 76th Session of the Texas Legislature enacted Senate Bill 103, mandating implementation of a new statewide testing program. The new testing requirements, subsequently named the Texas Assessment of Knowledge and Skills (TAKS), were implemented in spring 2003. In the spring of 2012, a new test was implemented that took the place of the TAKS. This test is called the STAAR or EOC for

End of Course exam. Unlike the TAKS which test prior year math concepts, the STAAR focused on Algebra 1 Texas Essential Knowledge and Skills (TEKS).

The assessment test, in this study, contained 39 multiple choice questions selected by the school district that addressed the readiness standards of the 9th grade STAAR. This test evaluated the student's knowledge and skills in the following reporting categories: (a) functional relationships (b) properties and attributes of functions (c) linear functions, (d) linear equations and inequalities, and (e) quadratic and other nonlinear functions.

Procedure

The treatment section of this study lasted 9 weeks. It was conducted during the weekly instructional time (48 minutes). There was 8 classes of participants, divided into 4 groups, with at least 20 students conveniently selected. The teachers were from the same subject area (Algebra 1) and they were teaching like they normally teach their subject but with various technologies in 3 different sections.

Pre-treatment procedures

There was 2 pre-treatment meetings that occurred during school hours: (a) the first meeting occurred as an introductory meeting to the study and (b) the second meeting occurred for the participants to complete all the pre-assessments.

In the first meeting, this study was discussed in detail. The students were kept blind about the control group and the treatment groups' selection to discourage any bias in group between or within the groups. Any questions by the participants were addressed.

In the second pre-treatment meeting, the participants completed the motivational survey and the STAAR pretest simultaneously. As the participants entered the room, they were each given the assessment tools with the collection documents to record their answers. Each student only recorded their district provided personal ID number on each assessment. Upon completion of both of the assessments, the students folded both assessments in half and I collected them. At the end of the session, I entered the data in SPSS. The original documents are stored in a locked file cabinet. I have the only key. The original and group data is password protected from anyone retrieving the information from my computer.

Treatment and non-Treatment Procedures

The treatment and the non-treatment groups were taught using the same curriculum and the same routine that normally takes place during each class period. The treatment groups however, used various technologies (see Table 2) while the control group used no technology. Each teacher had 3 treatment classes and 1 non-treatment class. The teachers were labeled as teacher A and teacher B. The classes were labeled A_1 thru A_4, for teacher A and B_1 thru B_4 for teacher B (see Table 3). The treatment groups received 9 weeks of technology usage while the control group used no technology (see Table 3 for groups and treatment).

Table 2

Description and Application of Technology

Name	*Description/Application*
Clicker Technology	Handheld answering devices that interact with the teacher's station computer. This device was used as an assessment tool.
TI - Nspire calculators with the	TI Nspire calculators was used by students to perform numerical calculation and graphical representation of data.
TI- Navigators	TI navigators was used with the calculators to connect the students' calculators interactively for visually monitoring students' calculator screens for assessment and immediate feedback of student's performance

Table 3

Groups Tests and Treatment

Groups	Pretest	Treatment	Posttest
A_1 and B_1 Group 1 (Control)	MSLQ STARR Test	None	MSLQ STAAR test
A_2 and B_2 Group 2	MSLQ STAAR test	TI Nspire calculators	MSLQ STAAR test
A_3 and B_3 Group 3	MSLQ STARR test	TI Nspire calculators TI Navigator	MSLQ STAAR test
A_4 and B_4 Group 4	MSLQ STARR test	TI Nspire calculators TI Navigator E-Instruction Clickers	MSLQ STAAR test

Variables

A list of the variables and their descriptions are given in Table 4.

Dependent variables

The dependent variables were the test scores and the numbers generated from the survey tools (see Table 5 for a list of the dependent variables).

Independent variables

The independent variables consisted of the interactive technology – TI Nspire Calculator used independently, then the TI Nspire Calculators with the navigator and then the E-Instruction clickers was added to the previous technologies (see Table 4 for a list of the independent variables).

Table 4

Variables - Descriptions

Variables	Description
Motivational Survey scores	The scores from the Motivational survey
Test Score	The scores from the pre and posttest
E-Instruction Clicker Technology	An interactive handheld device given to each student for the purpose of interacting in the learning environment.
TI Navigator	Texas Instruments wireless interactive system that displays student's calculator screens on a data projector.
TI Calculators	Hand held calculators that provide touchpad navigation, dynamic graphing, and interactive computer features.

Table 5

Variables

Dependent Variable	Independent Variables
Test Scores	TI Nspire calculators only
Motivational level	TI Nspire calculators with the TI navigator
	TI Nspire calculators with the TI navigator and the E-instruction Clickers

Post-treatment procedure

After 9 weeks of treatment, all groups took the motivational questionnaire and the assessment test simultaneously again. As the participants entered the room, they were each given the assessment tools with collection documents to record their answers. The students only entered their district provided personal ID on both assessment tools. Upon completion of both of the assessments, the students folded both assessments in half then I collected them. I entered the assessment results in Excel and SPSS. The computer and both software programs are password protected.

Data Collection Plan and Analysis

There were 2 methods used to collect data in this research study, (a) the questionnaire method and (b) the testing method. The Statistical Package for Social Science (SPSS) graduate pack version 21 analyzed the data collected from this study.

SPSS was used to complete the following analysis: (a) a paired sample t-test analysis of the difference between two means and (b) a factorial repeated ANOVA.

Descriptive Statistics

Descriptive Analysis was used to describe, explore and compare data within each group and between each group. *Frequency distributions* tables were used to show the various data collected. The frequency distribution tables were also converted to graphs to give a visual perspective of the data. Statistical data from the results of both groups on the pre and post achievement test and the pre and post motivational test was summarized in Tables 6 and 7 (also see table F48).

Table 6

STAAR Summary Statistics for Groups A and B

	Control Group – Group A					Treatment Group – Group B				
Test	N	Mean	Median	Mode	s	N	Mean	Median	Mode	s
Pre Test	21	31.30	29.40	47[a]	12.5	17	32.80	33.30	33[a]	12.1
Post Test	21	40.04	38.78	23[a]	13.1	17	39.50	41.20	23[a]	11.3

a - Multiple modes exist. The smallest value is shown

Table 7

STAAR Summary Statistics for Groups C and D

	Treatment group - group C					Treatment group - group D				
	N	Mean	Median	Mode	s	N	Mean	Median	Mode	S
Pre-Test	20	22.00	20.30	3[a]	14.4	18	23	26	0[a]	14
Post-Test	20	39.93	37.44	17[a]	14.81	18	41.9	39.60	22[a]	11.20

a - Multiple modes exist. The smallest value is shown

Hypothesis Testing

Hypothesis testing, using factorial repeated ANOVA and t-test analysis to analyze each category of the MSLQ and the STAAR, *was* used to reject or accept the null hypothesis.

The null hypotheses are listed below:

$H_0$1: There is no significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators.

$H_0$2: There is no significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator.

$H_0$3: There is no significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator and the clicker.

$H_0$4: There is no significant increase in students' test scores when using the TI Nspire calculators.

$H_0$5: There is no significant increase in students' test scores when using the TI Nspire calculators with the TI navigator.

$H_0$6: There is no significant increase in students' test scores when using the TI Nspire calculators with the TI navigator and the clicker technology.

The significance level or alpha for testing of the hypothesis was .05 or 5%. This analysis was performed during the factorial repeated –measures ANOVA cycle using SPSS.

Paired Sample t-testing

The paired sample t-testing or dependent t-test was used for the categorical sections of the MSLQ and the STAAR. The paired sample t-test are parametric test that are based on the following 4 assumptions:

- The sampling distribution is normal
- Data are measured at the interval level
- Homogeneity of variance
- And the scores are independent (Field, 2009, p.326)

The paired sample t-test output included a the following: a paired sample statistics table, a paired sample of Pearson's correlations with 2 tailed significance value, and the sample t-test with 2-tailed significance value.

Factorial Repeated Analysis of the Variance (ANOVA)

The factorial repeated analysis of the variance (ANOVA) was used for hypotheses testing using the grand totals from the MSLQ (pre and post grand totals) and the STAAR pre and post grand totals). The factorial repeated analysis of the variance produced the following analysis of the data:

- Description of the within and between subject factors
- Descriptive statistics of the factors
- Box's Test of Equality of Covariance
- Mauchly's Test of sphericity
- Multivariate Test
- Within subjects Effects test

- Within subjects contrasts
- Between subjects effects
- Contrast results (K Matrix)
- Fisher Least significant difference

Reliability and Validity

Reliability and validity according to Tashakkori and Teddlie (2003) "are the two qualities most central to assessment of the 'goodness' of a measurement" (p. 581).

Reliability

Reliability for both the survey instrument and the non-survey instrument was established using the "test-retest" reliability method. This method was established by giving both groups the same survey and the same test twice. The main problem with this method, according to Trochim (2001), is that "you don't have any information about reliability until you collect the posttest and if the reliability estimate is low, you're pretty much sunk" (p.101). Johnson and Christensen (2008) stated another problem with the "test retest" reliability method with the following statement:

One of the problems with assessing test-retest reliability is knowing how much time should elapse between the two testing occasions. If the time interval is too short, the participants will remember how they responded when they took the test the first time and if the time interval is too long the responses might be due to changes in the participants. (p. 146)

The time limit for this study was conducted for nine weeks. This allowed sufficient time for the students to forget the items on the first test and this interval was not too long that changes in the participants would affect the results of the posttest.

Validity

The threats to validity in a quasi-experimental nonequivalent control group design are reduced by using a control group. But Lunenburg and Irby (2008) warn that nonequivalent groups also face a threat of selection that can be controlled by giving multiple pretests (p.50). Lunenburg and Irby (2008) also made the following statement concerning the control of validity in research:

> Internal validity is reached by establishing causal relationships in which certain conditions were shown to lead to other conditions. External validity is established in a study when the results of that study can be generalized to the population. Finally, construct validity is accomplished by establishing clearly specified operational procedures. (p.103)

Controlling internal validity threats. In this study, internal validity was established when it was certain that the treatment caused the effect observed. In the NEGD the biggest threat to internal validity is in the selection process because random assignment of groups was not used. The *selection-history threat* could reveal that some students may have been exposed to the treatment in prior classes and have already developed a positive or negative reaction to technology used in the classroom. In the *selection-maturation threat* many of the students were of various ages and had a more mature perspective about learning math between the administration of the pretest and the posttest. The selection threats was controlled by keeping this study to only nine weeks and making sure that the students were not exposed to the selected technology prior to this study.

The following *social threats to internal validity* maybe possible during the administration of the treatment: (a) diffusion or imitation of treatment – where students not in the treatment group could fake or imitate the treatment group, (b) compensatory rivalry – students in the control group might develop a competitive rival attitude toward the treatment group that would increase their scores and effect the true scores from the treatment group, (c) resentful demoralization – students in the control group become discouraged or angry with the students in the treatment group and become more less focused during the lesson and learning, and (d) compensatory equalization of the treatment might occur if the researcher or school administration is pressured to move certain students into the treatment group. Social threats to internal validity was controlled by blinding the identity of which group was the control and which group was the treatment from the participants.

Controlling external validity threat. The nature of this research design, quasi-experimental design, made generalizations impossible. External validity was weaken and biased by the research design because randomization was not used.

Controlling construct validity threat. Construct validity and reliability was increased for the survey instrument by using a Likert scale. "The key advantages of multiple-item rating scales compared to single-item rating scales are that multiple-item scales provide more reliable scores and they produce more variability, which helps the researcher make finer distinctions among the respondents" (Johnson & Christensen, 2008, p. 185). The reliability and validity of the MSLQ has been tested by hundreds of researchers and instructors as a reliable tool for measuring motivation. Pintrich and Others (1991) made the following statement about the validity of the MSLQ, "we tested for the factor validity of the MSLQ scales by running two confirmatory analyses: one for the set of motivation items and another for the set of cognitive and metacognitive strategy items. The Lisrel 6 was used to estimate and test our models." (p.79).

The Non-survey instrument established validity by using predictive validity. Predictive validity compared the test scores of all students with their performance in the classroom on activities and test. "Criterion-related evidence of validity for the Texas Assessment of Knowledge and Skills (TAKS) was provided in a study conducted by Texas Education Agency (TEA) and Pearson Educational Measurement (PEM) to fulfill the Senate Bill 103 requirement that TEA implement a college readiness component as part of the TAKS" (Technical Digest, 2006, p. 179). In spring 2011, the students took the STAAR test instead of the TAKS. The STAAR was based on the same TEKS that were used with the TAKS. So I concluded that the validity for the TAKS and the STAAR were the same criteria.

Research Ethics

Research ethics defined by Sproull (1988) are "those practices and procedures which lead to the following: (a) protection of human and non-human subjects, (b) appropriate methodology, (c) inferences, conclusions and recommendations based on the actual findings, and (d) complete and accurate research reports" (p.8). In this section of the study the following ethical issues was supported: (a) the protection of participants, and (b) the accurate and complete reporting of the data, data analysis, inferences, and conclusions.

Protection of Participants

The protection of the participants deals with getting the participants voluntary consent, disclosing to the participants all of the aspects related to the study, protecting the participants from any harm whether mental or physical, keeping their identity anonymous and allowing them to withdraw from the study at any time.

Voluntary consent. The participants were given the right to freely consent or deny participation in this study without retribution. No form of coercion was applied to the participants in this study and no form of coercion was used to force the participants to remain in this study.

Informed Consent. "Federal regulations as well as the guidelines established by the American Educational Research Association (AERA) states that research participants must give informed consent before they can participate in a study" (Johnson & Christensen, 2008, p. 109). Consent forms were not given because the school decided to conduct this study as benchmark testing to help the teachers prepare the students for the actual STAAR test (See Appendix B for the IRB approved consent and assent form).

Protection from mental and physical harm. No participant was placed in a position or situation where he or she might be at risk of physical or emotional harm as a result of their participation in this study. Ethical standards require that researchers not put participants in a situation where they might be at risk of harm as result of their participation.

Confidentiality, anonymity, and privacy. The confidentiality, anonymity, and privacy of the participants were preserved during the data collection, analysis, and interpretation by disassociating the students' identification from responses during the coding and recording process. Mills (2003) quoted Flinders (1992) with the following statement about confidentiality, "confidentiality is important for the following reasons: (a) confidentiality is intended to protect research informants from stress, embarrassment, or unwanted publicity, and (b) confidentiality protects participants in situations where the information they reveal to a research can be used against them by others" (p. 92). The participants completed pre and post MSLQ and the pre and post STAAR without placing their names on the documents. Only the researcher had access to data.

Debriefing. At the conclusion of this study, the participants were informed of the results in an interactive group presentation. According to Johnson and Christensen (2008) "during the debriefing the researcher should be available to answer any questions the participant may have, and, more important, to ensure that the participant is adequately dehoaxed if deception is used and desensitized if made to feel uncomfortable" (p.126). Finally the participants were assured that their reactions were normal and their participation was greatly appreciated.

Accurate Research Preparation and Reporting

Accurate authorship was given in this study. "Authorship should be confined to those individuals who have made a substantial contribution to the conceptualization, design, execution, analysis, or interpretation of the study being reported" (Johnson & Christensen, 2008, p.127). All data, data analysis and conclusions were accurately reported without bias. According to Sproull (1988), "all researchers have the obligation to report their research methodology, findings, and conclusions in a complete and unbiased manner" (p.13). Reporting negative findings and any errors in the procedures should also be reported (Sproull, 1988, p.13). Johnson and Christensen (2008) also stated the following about accurate reporting of research findings:

> You should never fabricate or falsify any information presented, and you should report the methodology used in collecting and analyzing the data as accurately as possible and in a manner that allows others to replicate the study and draw reasonable conclusions about its validity. (p.127)

Summary

In summary, I analyzed and synthesized the effects of student's motivation in the classroom before and after the use of interactive technology by analyzing their test results and the results from a motivational survey. I used a quantitative method and a quasi-experimental design that measured numerically the level of the students' motivation and the effects of motivation on academic performance. I used 2 methods to collect data in this research study, (a) the questionnaire method and (b) the testing method. I used the Statistical Package for Social Science (SPSS) graduate pack version 21 to analyze the data collected from this study. I used SPSS to complete the following analysis: (a) a paired sample t-test analysis of the difference between two means and (b) a factorial repeated ANOVA. In Chapter 4 I proved using SPSS a relationship with the groups on the assessment test but I no statistical significant was observed with the MSLQ.

Chapter 4: Data Presentation and Analysis

Introduction

In this study, ninth grade, first year students were selected as the participants. These students were in the 8th grade last year and they took the eighth grade State of Texas Assessment of Academic Readiness (STAAR). I used convenient sampling to select four classes for this study. The original sample size was four classes of 185 students (see Table 8) but because of absences, students dropping out of school, students transferring to other schools and classes during the collection stage, my actual sample was reduced to 76 students.

Table 8

Original and Actual Sample Size

Group name	Group type	Original sample	Actual sample
1	Control	51	21
2	Nspire	37	17
3	Nspire, navigator	51	20
4	Nspire, navigator, clickers	46	18
Totals		185	76

I conducted this study over a 9 week period. Each group actually contained two classes of students. All participants were allowed the use of any calculator on the pre-assessments of the STAAR, but during the treatment Group 1 did not use a calculator, Group 2 used the TI Nspire calculator, Group 3 used the TI Nspire calculator with the TI navigational system, Group 4 used the TI Nspire calculator with the TI navigational system and E-instruction clickers. I conducted the statistical analysis on the data to answer the following research questions:

1. Does interactive technology, the TI Nspire calculators, provide the stimulus or "action" needed to increase students' motivation and interest in the mathematical classroom?
2. Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or "action" needed to increase students' motivation and interest in the mathematical classroom?
3. Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' motivation and interest in the mathematical classroom?
4. Does interactive technology, the TI Nspire calculators, provide the stimulus or "action" needed to improve students' test scores?
5. Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or "action" needed to improve students' test scores?
6. Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' test scores?

Those same statistical analysis were also used in the analysis of the following alternative hypotheses about the use of technology:

$H_1 1$: There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators.

$H_1 2$: There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator.

$H_1 3$: There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator and the clicker.

$H_1 4$: There is a significant increase in students' test scores when using the TI Nspire calculators.

$H_1 5$: There is a significant increase in students' test scores when using the TI Nspire calculators with the TI navigator.

$H_1 6$: There is a significant increase in students' test scores when using the TI Nspire calculators with the TI navigator and the clicker technology.

Descriptive Statistics: Participants

The participants in this study were first year freshmen between the ages of 14 and 15. However, the age of the participants were not considered a variable in this study. The teachers' teaching experience ranged from 15 years to 3 years. The veteran teachers were the teachers with the control group, while the least experienced teachers from 7 to 3 years had the technology groups. Table 9 shows the group type, by gender, of the participants. The totals are similar while the distribution between the males and females are little disproportional in Groups 2 and 3.

Table 9

Gender by Group

		Group 1 Control	Group 2 Nspires	Group 3 Nsprires Navigators	Group 4 Nspires navigators clickers	total
Gender	Female	10	10	8	3	31
	Male	11	7	12	14	44
Total		21	17	20	18	76

Paired Sample T-test Data Analysis: MSLQ

I gave the MSLQ, Motivated Strategies for Learning Questionnaire as a pretest and posttest to all the students. The MSLQ contained 30 questions to test the participants in 5 categories. Category 1, the intrinsic goal questions, tested the participant's perception of the inherent reasons why he or she engaged in the learning task. Examples of intrinsic goals might include the participant's personal challenges, curiosity, or just the mastering of a learning task (I averaged questions: 1, 16, 22, and 24 for that category).

In category 2, the extrinsic goal questions, I tested the participant's perception of any external reasons why he or she were not engaged in a learning task. Examples of extrinsic goals include the participant's desire for grades, some type of reward expected, personal performance desires, a competitive desire, or personal evaluations by others during a learning task (I averaged questions: 7, 11, 13, and 30 for that category). In category 3, the task value questions, I tested the participant's perception of how interested, or how important, or how useful the task was to him or her (I averaged questions: 4, 10, 17, 23, 26 and 27 for that category).

In category 4, the control of learning behavior questions, I tested the participant's perception of their expected outcome of the learning task. Examples of control of learning behavior goals might include the participant's perception that his or her efforts to learn resulted in a positive outcome during a learning task (I averaged questions: 2, 9, 18, and 25 for that category). In Category 5, the self-efficacy questions, I tested the participant's perception of the learning task. These questions revealed the student's belief about his or her success while completing a learning task. (I averaged questions: 5, 6, 12, 15, 20, 21, and 29 for that category). Finally, in Category 6, test anxiety questions, I tested the participant's perception of any anxiety while testing (I averaged questions: 3, 8, 14, 19 and 28 were averaged for that category). There were three research questions and three hypotheses based on the MSLQ that I analyzed in this section. They are research questions 1, 2, and 3 and hypothesis 1, 2, and 3.

Category 1: Intrinsic Values.

In the next six tables, Tables E11-E13, I conducted a paired t-test on the data which displayed the means of each group in each category of the MSLQ. The Intrinsic goals focused on the students' inner reasons or internal reasons for participating in a course. These goals defined why the students participated in the learning environment of this Algebra 1 class. The results of the different mean values of Table E11 shows an increase in those goals from the pretest to the posttest, but the large number for standard deviations tell that the variation of the data around the mean is densely dispersed. Group 1 had a 2 point increase in its means, Group 2 and Group 1 had a 1 point increase in its means, and Group 4 had a 2 point increase in its means. Since the means are all significantly close together, there can be no obvious conclusion for the use of technology when referring to students' intrinsic goals.

I conducted a Pearson Correlation (two-tailed, $p < .05$) which analyzed any linear relationship between the pretest and posttest of each group (see Table E12). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results except for the students in Group 2. Group 2 used the TI Nspire calculators only. Group 2 had a correlation coefficient of .810 and a *p*-value less than .05. This meant that a positive linear relationship was statistically present between the pre and the posttest with Group 2 in this category. If a student in Group 2 scored high on the pretest then he or she also scored high on the posttest. If a student scored low on the pretest then he or she also scored low on the posttest.

In the paired *t*-test the difference in the means between the pretest and the posttest in Category 1 was analyzed. The results of a 2-tailed significance (see Table E13) revealed that there was no significant difference between the pretest and the posttest for any of the groups using technology. Intrinsic values were not affected by the use of technology for any of the treatment groups

Category 2: Extrinsic values.

The extrinsic goals (see Table E14) displayed the different groups' statistics related to the students' outer reasons or physical reasons for participating in an Algebra 1 class. The means of each of the groups are close together except for Group 4. Group 1 had a 1 point increase in its means, Group 2 had a decrease of less than 1 point in its means, Group 3 had less than a 1 point increase in its means, and Group 4 had a 4 point increase in its means. Group 4 was the group that used all of the technology, TI Nspire calculators, the TI navigator, and the E-instruction clickers.

I used Pearson Correlation (two-tailed, $p < .05$) to analyze any linear relationship between the pretest and posttest of each group (see Table E15). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results except for the students in Group 2. Group 2 used the TI Nspire calculators only. Group 2 had a correlation coefficient of .733 and a *p*-value less than .05. This meant that a positive, linear relationship was present between the pre and the posttest with Group 2 in this category. If a student in Group 2 scored high on the pretest then he or she also scored high on the posttest. If a student scored low on the pretest, then he or she also scored low on the posttest.

In the paired *t* test the difference in the means between the pretest and the posttest in Category 2 were analyzed. The results of a 2-tailed significance (see Table E16) revealed that there was no significant difference between the pretest and the posttest for any of the groups using technology. Extrinsic values were not affected by the use of technology for any of the treatment groups

Category 3: Task value

This category refers to the goals that were related to the students' belief about how interesting, important, and useful the information was while they were participating in the learning environment. The statistics are displayed in Table E17 and an observation of the data revealed a very close means between the groups except for a 2 point increase in Group 4, the group that utilizes all of the interactive technology.

I used the Pearson Correlation (two-tailed, $p < .05$) to analyze any linear relationship between the pretest and posttest of each group (see Table E18). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results except for the students in Group 2. Group 2 used the TI Nspire calculators only. Group 2 had a correlation coefficient of .759 and a p-value of .011 which is less than .05. This meant that a positive linear relationship was statistically present between the pre and the posttest with Group 2 in this category. If a student in Group 2 scored high on the pretest then he or she also scored high on the posttest. If a student scored low on the pretest then he or she also scored low on the posttest.

In the paired *t* test the difference in the means between the pretest and the posttest in Category 3 was analyzed. The results of a 2-tailed significance (see Table E19) revealed that there was no significant difference between the pretest and the posttest for any of the groups using technology. Task Value goals were not affected by the use of technology for any of the treatment groups.

Category 4: Control of learning beliefs

This category refers to the students controlling their own learning behavior. The students believed that hard work would result in a positive outcome. This statistic is displayed in Table E20. Group 1 had a 3 point increase in the mean, Group 2 had less than 1 point increase in the mean, Group 3 had about 1 point increase in the mean, and Group 4 had 3 point increase in the mean. Since Group 1, the control group and Group 4, the group using 3 types of interactive technology, had the same amount of increase, I concluded that the use of technology was not significant in this category, with respect to the mean values.

I used Pearson Correlation (two-tailed, $p < .05$) to analyze any linear relationship between the pretest and posttest of each group (see Table E21). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results except for the students in Group 2 and Group 3. Group 2 used the TI Nspire calculators only. Group 2 had a correlation coefficient of .691 and a *p*-value of .002 (which is less than .05). Group 3 used the TI Nspire calculators with the navigator. Group 3 had a correlation coefficient of .319 and a *p*-value of .05. A positive, statistically significant, linear relationship was present between the pre and the posttest with Groups 2 and 3 in this category. If a student in Groups 2 or 3 scored high on the pretest, then he or she also scored high on the posttest. If a student in these groups scored low on the pretest then he or she also scored low on the posttest.

In the paired *t* test I analyzed the difference in the means between the pretest and the posttest in Category 1. The results of a 2-tailed significance (see Table E22) revealed that there was no significant difference between the pretest and the posttest for any of the groups using technology. The students having the ability to control their behavior in a learning environment was not affected by the use of technology for any of the treatment groups. The Group 1, the control group, did reveal a significant *p*-value, but no treatment was administered to this group. So the significance is unidentifiable.

Category 5: Self Efficacy for Learning and Performance

The comparison between the means in this category is called self-efficacy for learning. This goal focused on the students' expectations of success in the class and a self-evaluation of their ability to perform the task needed in this course. Observing the self-efficacy Table (Table E23), the mean values for Group 1 increased by 1 point, the mean value for Group 2 increase by 2 points, the mean value for Group 3 increased by 1 point, and the mean value for Group 4 increased by less than 1 point. I would conclude by the values of the means that technology had no effect on this category.

The Pearson Correlation (two-tailed, $p < .05$) analyzed any linear relationship between the pretest and posttest of each group (see Table E24). The analysis revealed that all of the groups had a significant linear relationship between the pretest and the posttest results. Group 1 the control group, received a correlation coefficient of .480 with a *p*-value of .02. Group 2 using the TI Nspire calculators only, received a correlation coefficient of .731 and a *p*-value of .011. Group 3 using the TI Nspire calculators with the TI Navigator, received a correlation coefficient of .502 and a *p*-value of .001. Group 4 using the TI Nspire calculators, the TI Navigator, and the clickers received a correlation coefficient of .524 and a *p*-value of .026. This meant that a positive linear relationship was statistically present between the pre and the posttest for all the groups in this category. If a student in any group scored high on the pretest then they also scored high on the posttest. If they scored low on the pretest then they also scored low on the posttest.

In the paired t-test the difference in the means between the pretest and the posttest in category 5 was analyzed. The results of a 2-tailed significance (see Table E25) revealed that there was no significant difference between the pretest and the posttest for any of the groups using technology. The self-efficacy for learning values were not affected by the use of technology for any of the treatment groups

Category 6: Test Anxiety

In the final category test anxiety was observed. This category focused on 2 areas related to test anxiety: (1) how the students worry about their performance on a test and (2) how the students are preoccupied with negative thoughts while testing. In Table E26, Group 1, the control, had the largest increase from pretest to posttest. Group 2 had a decrease of a negative 1, Group 3 had a gain of 1, Group 4 had a gain of 1 point to the mean value. In this category, Group 1 showed the highest gain in test anxiety. In this category the group not using any treatment displayed signs of test anxiety.

Using the Pearson Correlation (two-tailed, $p < .05$) I analyzed any linear relationship between the pretest and posttest of each group (see Table E27). This analysis revealed that there were no significant linear relationship between the pretest and the posttest results except for the students in Group 2. Group 2 used the TI Nspire calculators only. Group 2 had a correlation coefficient of .570 and a p-value of .017 which is less than .05. This meant that a positive linear relationship was statistically present between the pre and the posttest with Group 2 in this category. If a student in Group 2 scored high on the pretest then he or she also scored high on the posttest. If a student scored low on the pretest then he or she also scored low on the posttest.

In the paired t-test I analyzed the difference in the means between the pretest and the posttest in category 6. The results of a 2-tailed significance (see Table E28) revealed that there was no significant difference between the pretest and the posttest for any of the treatment groups. . Test Anxiety was not a factor that affected the students in any of the treatment groups.

MSLQ Grand Total

In the final statistical Table for the MSLQ, each category was averaged to get a final score called the grand total MSLQ for each group. That data is shown in Table E29. Group 1 total mean for the MSLQ increased by about 2 points, Group 2 total mean decreased by less than 1 point, Group 3 total mean increased by 1 point and Group 4 total mean increased by 1 point. In conclusion, a review of the mean values of the MSLQ revealed no significant increase.

The Pearson Correlation (two-tailed, $p < .05$) analyzed any linear relationship between the grand total scores of the pretest and the grand total scores for the posttest of the MSLQ. (See Table E30). The analysis revealed that there was no significant linear relationship between the pretest grand totals and the posttest grand totals except for the students in Group 2 and Group 3. Group 2 used the TI Nspire calculators only. Group 2 had a correlation coefficient of .769 and a *p*-value less than .05. Group 3 used the TI Nspire calculators with the navigator. Group 3 had a correlation coefficient of .465 and a *p*-value of .039. Both of the groups' data displayed a positive linear relationship that was statistically presented between the pretest and the posttest grand totals.

In the paired t-test, I analyzed the difference in the means between the pretest grand totals and the posttest grand totals. The results of a 2-tailed significance (see Table E31) revealed that there was no significant difference between the pretest grand totals and the posttest grand totals for any of the groups using technology. The grand totals of the pretest and the posttest of the MSLQ revealed no overall effect on the students' performance from the pretest to the posttest.

MSLQ Data Analysis summary

In the final analysis for the MSLQ results, there was no statistical significance between the pre-MSLQ and the post-MSLQ of any treatment group. No significance effect was statistically present within any category or grand total using a sample t-test analysis.

Paired Sample T-test Data Analysis: STAAR Test

The State of Texas Assessment of Academic Readiness Test, STAAR, was given as a pre and posttest to all the students. The pre-assessment was prepared and given by the school district to assess the current needs of the 9th grade students. This data was given to the teachers as a blueprint to follow while preparing the students for the actual STAAR test. The actual STAAR test was used as my posttest data.

Immediately after the pretest, I administered each group, the technology outlined in Table 10. The control group, Group 1, was given no treatment. Group 2 was given the use of the TI Nspire calculators. Group 3 was given the use of the TI Nspire calculators and the TI navigator. Group 4 was given the use of the TI Nspire calculators, the TI navigator, and the e-Instruction clickers.

Table 10

Actual Groups and Treatment

Groups	Treatment
Group #1	None
Group #2	TI Nspire calculators
Group #3	TI Nspire calculators TI Navigator
Group #4	TI Nspire calculators TI Navigator E-Instruction Clickers

The state required STAAR test was used to acquire the post-test data. Both test assessed the student's readiness in the following 5 categories:

- Reporting category 1, assessed students' understanding of functional relationships;

- Reporting category 2, assessed the students' understanding of properties and attributes of functions;
- Reporting category 3, assessed the students' understanding of linear functions;
- Reporting category 4, assessed the students' understanding of linear equations and inequalities;
- And reporting category 5 assessed the students' understanding of quadratic and other non-linear functions.

In Tables F32-F49, the statistics represented the STAAR test from the perspective of the reporting categories using the paired t-test statistics.

STAAR Reporting Category 1

In the first reporting category, the students' understanding of functional relationships was represented in Table F32. From pretest to posttest in this category, every group means increased by double digits except Group 2, the group with the Nspire only technology. Even the control group, Group 1 increased by about 12 points. The most gain in the mean is shown by Group 3, the group with 2 types of technology. Group 3 means increased by 27 points from the pretest while Group 4, the group with all of the technology mean increase by 24 points. The results in this category shows a significant increase for the groups using 2 or more interactive technology.

The Pearson Correlation (two-tailed, $p < .05$) analyzed any linear relationship between the pretest and posttest of each group (see Table F33). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results in reporting category 1 for any of the groups.

In the paired t-test the difference in the means between the pretest and the posttest in reporting category 1 was analyzed. The results of a 2-tailed significance (see Table F34) revealed that there was a significant increase in the students' performance in reporting category 1 for Group 3 and Group 4. Group 3 used 2 different types of technology and had the following statistics (*M*=-26.47, *SE*=28.62), $t(19)=-4.10$, $p = .001$, and $r = .14$. Group 4 used 3 different types of technology and had the following statistics (*M*=-23.85, *SE*=26.70), $t(17)=-3.80$, $p = .001$, and $r = .13$. The students in groups 3 and 4 showed a significant increase in their understanding of functional relationships from the pretest to the posttest.

STAAR Reporting Category 2

In category 2, (see Table F35) which is based on the students understanding of properties and attributes of functions, all the groups' means increased except for Group 2. Group 2 had a mean that decreased by 3 points. Group 1, the control group, increased its mean by only 3 points while Group 3 means increased by 21 points and Group 4 means increased by 26 points. The results in this category revealed a significant increase for the groups using 2 or more interactive technology.

The Pearson Correlation (two-tailed, $p < .05$) analyzed any linear relationship between the pretest and posttest of each group (see Table F36). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results in this reporting category except for the students in Group 1. Group 1, the control group, received a correlation coefficient of.584 and a *p*-value of .005. Group 1 also received no technology treatment but Group 1 data had a positive linear relationship that was statistically present between the pre and the posttest in this category. If a student in Group 1 scored high on the pretest then he or she also scored high on the posttest. If a student scored low on the pretest then he or she also scored low on the posttest.

In the paired t-test, I analyzed the difference in the means between the pretest and the posttest on STAAR reporting category 2. The results of a 2-tailed significance (see Table F37) revealed that there was a significant increase in the students' performance in category 2 for Group 3 and Group 4. Group 3 used 2 different types of technology and had the following statistical values, (M=-21.40, SE=24.50), t(19)=-3.91, p = .001, and r=-.03. Group 4 used 2 different types of technology and had the following statistical values, (M=-25.93, SE=26.20), t(17)=-4.20, p = .001, and r =.05. The students in groups 3 and 4 showed a significant increase in their understanding of properties and attributes of functions on the STAAR test.

STAAR Reporting Category 3

In category 3 (see Table F38) which measured the students' understanding of linear functions, all of the groups' means increased except for Group 2. Group 2 had a mean that decreased by 2 points. Group 1, the control group had a mean that increased by 5 points. Groups 3 and 4 had double digit increases in their means. Group 3 had a 17 point increase from pre to posttest, while Group 4 had a 16 point increase from pre to posttest. The results for this category, by analyzing the means, produced a significant increase for the groups using 2 or more interactive technology.

The Pearson Correlation (two-tailed, $p < .05$) analyzed any linear relationship between the pretest and posttest of each group (see Table F39). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results on the STAAR reporting category 3 for any of the groups.

In the paired t-test I analyzed the difference in the means between the pretest and the posttest in STAAR reporting category 3. That analysis revealed using a 2-tailed significance (see Table F40) that there was a significant difference between the pretest and the posttest for groups 3 and 4. Group 3 statistical data was (M=-17.00, SE=18.95), t(19)=-4.00, p=.001, and r =.30. Group 4 statistical data was (M=-15.75, SE=23.85)

t (17)=-2.80, p =.01, r =.14. The students' in groups 3 and 4 showed a significant understanding of linear equations and inequalities on the STAAR test due to the use of technology.

STAAR Reporting Category 4

In category 4 (see Table F41) which measured the students' understanding of linear equations and inequalities, all of the groups' mean increased. Group 1 mean increased by 15 points, Group 2 mean increased by 16 points, Group 3 mean increased by 9 points and Group 4 mean increased by 19 points. The group that increased by the most points, used 3 different types of interactive technologies.

Using the Pearson Correlation (two-tailed, $p < .05$), I analyzed any linear relationship between the pretest and posttest of each group (see Table F42). That analysis revealed that there were no significant linear relationship between the pretest and the posttest results in reporting category 4 for any of the groups.

In the paired t-test, I analyzed the difference in the means between the pretest and the posttest in category 4. The results of that analysis using a 2-tailed significance (see

Table F43) revealed that two of the treatment groups and the control group had a significant difference between the pretest and the posttest for STAAR reporting category 4. Group 1 had the following statistical values, (*M*=-14.78, *SE*=23.70) $t(20)=-3.00$, p = .01, and r =.19. However Group 1 did not receive any technology treatment. Group 2 had the following statistical values, (*M*=-15.70, *SE*=23.08) $t(16)=-2.80$, p = .01,and r =.31.Group 2 treatment only consisted of using the TI Nspire calculators. Group 4 had the following statistical values, (*M*=-19.45, *SE*=29.33), $t(17)=3.00$, p = .01, and r =-.21. Group 4 used all of the interactive technology, the TI Nspire calculators, the TI navigator, and the e-Instructions clickers. In conclusion groups 2 and 4 showed a significant effect in the area of students understanding of linear equations and inequalities from the STAAR pretest to the STAAR posttest.

STAAR Reporting Category 5

In Table F44, the students understanding about quadratic and other nonlinear functions were measured. All groups showed an increase in their mean values. Group 1 mean value increased by 8 points, Group 2 mean value increased by 16 points, Group 3 mean value increased by 15 points and Group 4 mean value increased by 8 points. The most significant increase was shown by Group 2 and Group 3. The control group and the group using the most interactive technology had the same amount of increase.

The Pearson Correlation (two-tailed, $p < .05$) analyzed any linear relationship between the pretest and posttest of each group (see Table F45). The analysis revealed that there were no significant linear relationship between the pretest and the posttest results in reporting category 5 for any of the groups.

In the paired t-test the difference in the means between the pretest and the posttest in category 5 was analyzed. The results of a 2-tailed significance (see Table F46) revealed that there was no significant difference between the pretest and the posttest for Group 1, the control group, and Group 4, the group that used 3 different types of technologies. However, Group 2 and Group 3 did show a significance between the pretest and the posttest mean. Group 2 had the following statistical values (M=-15.70, SE=23.08), $t(16)$=-2.80, p = .01, and r =.31. Group 3 had the following statistical values (M=-15.97, SE=25.92), $t(19)$=-2.72, p = .01, and r =.41. Group 2 used the TI Nspire calculators. In conclusion, the students in Group 2 and Group 3 showed a significant increase of their understanding about quadratics using technology.

STAAR Grand Totals

In the final mean analysis of the STAAR, Table F47, the grand total means for each group was analyzed and a graphical representation of the data can be viewed in Figure 5. All of the groups showed a significant improvement in the mean value of their grand totals. Group 1 increased its grand total mean value by 9 points, Group 2 increased its grand total mean value by 7 points, Group 3 increased its grand total mean value by 17 points and Group 4 increased its grand total mean by 18 points.

Using the Pearson Correlation (two-tailed, $p < .05$), I analyzed any linear relationship between the grand total pretest and the grand total posttest of each group (see Table F48). This analysis revealed that there were no significant linear relationship between the pretest grand totals and the posttest grand totals except for the grand totals in Group 2 and Group 3. Group 2 used the TI Nspire calculators only. Group 2 received a

.769 correlation coefficient with a p-value less than .05. Group 3 used two different types of technology, the TI Nspire calculators and the TI navigator. Group 3 received a correlation coefficient of .465 and a p-value of .039.

In the paired *t*-test I analyzed the difference in the means between the pretest grand totals and the posttest grand totals for each group. That analysis using a 2-tailed significance (see Table F49) revealed a significant difference between the pretest grand totals and the posttest grand totals for 2 treatment groups. Group 3 had the following statistical values, (M=-17.90, SE=15.44) $t(19)$=-5.18, $p < .05$, and $r = .44$. Group 4 had the following statistical values, (M=-18.50, SE=13.67) $t(17)$=-5.76, $p < .05$, and $r = .41$. The results of the sample *t*-test analysis of the grand totals for each group revealed that the groups using 2 or more types of interactive technology showed a statistical improvement in their STAAR scores over all the categories.

STAAR Data Analysis Summary

There was some significant effects shown between the STAAR pretest and the STAAR posttest from each category and from the grand total scores. In STAAR reporting category 1, students ‘understanding of functional relationships, treatment Group 3 and Group 4, null hypotheses could not be rejected. In STAAR reporting category 2, students’ understanding of properties and attributes for functions, treatment Group 3 and Group 4 null hypotheses could not be rejected. In STAAR reporting category 3, the students’ understanding of linear functions, treatment Group 3 and Group 4 null hypotheses could not be rejected. In STAAR reporting category 4, the students’ understanding of properties and attributes for functions, treatment Group 2 and Group 4 null hypotheses could not be rejected. In STAAR reporting category 5, students' understanding of quadratics and other non-linear functions, treatment Group 2 and Group 3, null hypotheses could not be rejected. In the Grand Total STAAR results treatment Group 3 and Group 4, null hypotheses could not be rejected.

In conclusion, the control group showed a statistical effect in 1 out of 5 categories. Group 2 (used the treatment of the TI Nspire calculators) showed a statistical significance in 2 out of 5 categories. Group 3 (used the treatment of the TI Nspire calculators and the TI navigator) showed a statistical significance in 4 out of 5 categories. Group 4 (used the treatment of the TI Nspire calculators, TI Nspire navatigor, and e-Instruction clickers) showed a statistical significance in 4 out of 5 categories. These results indicate a significant advantage for using interactive technology in a mathematical classroom environment.

Testing the Research Questions

A factorial repeated-measures ANOVA analyzed the research questions. The following assumptions were made about the data when computing the factorial repeated ANOVA:

- There was homogeneity of variance. In Levene's test of homogeneity of the variance, Table G50, Levene's test is non-significant for the MSLQ and the STAAR test. This indicates that the variances are not significantly different but are similar.
- Interval data was used.

- And the data was independent of each other. The means the data from one participant does not influence the data of the other participants. This assumption has also been met.

In the factorial repeated-measures ANOVA, I compared the total scores from the participants from the MSLQ pretest and the total scores from the MSLQ posttest. The interaction between the two mean was named MSLQ. Next the total scores of the participants from the STAAR pretest was compared to the total scores of the participants from the actual STAAR test. That interaction yielded a variable called the STAAR (see Table G51 for the MSLQ and Table H62 for the STAAR)

MSLQ – Research Questions

In this section, I analyzed the first three research questions and their related hypotheses. The results of that data analysis is displayed in Tables G51 through G61 and Figure 2. In Table G51 and Table G52, the subject factors were identified. In Table G51, I compared the means of the pre and post grand totals of the MSQL. This analysis identified the "within subject factors." In Table G52, I used general statistics for each group pretest and posttest grand totals. The means were relatively the same across groups and between tests. The standard deviation was also relatively the same across all groups for both the pretest and posttest grand totals. In Table G53, I analyzed the factors or means between each group. This analysis identified the "between subject factors." In Table G54, the Mauchly test of sphericity revealed no significant value. If a repeated measure variable has only 2 levels the sphericity is met. This means that the difference between treatments or experimental conditions and between each pair of scores are approximately equal. In Table G55, the Box's test of equality of the covariance matrix was not significant. The Box statistic tested the assumption of equal covariance matrices. The Box statistic can be ignored if the sample sizes are equal. The sample sizes in this study were relatively equal (sample sizes - 21, 17, 20 and 18). In Table G56, test of within subject effects, within every effect, there was a significant difference between the pretest and the posttest grand totals. The results for all of the effects were the same, F (1, 76) =4.20, p=.04. Also in Table G56, there was a no-significant difference between the pretest and the posttest within the groups for all of the effects. The results for all of the effects also were the same, F (3, 72) =.65, p =.59. In Table G57, I used the multivariate test (MANOVA), with four test statistics (Pillai's Trace, Wilks's Lambda, Hotelling's Trace and Roy's Largest Root). The MANOVA, tested the differences between groups across several dependent variables. In Table G57, the multivariate test (MANOVA), using the pretest and the posttest grand totals, revealed a significant effect. The interaction of those test with the groups revealed no significant effect. Using Pillai's trace, to test the effect of the MSLQ grand totals, revealed a significant effect from the treatment between the MSLQ grand totals from the pretest to the posttest, V=.055, F(1,72)=4.20, p =.04. I used the Pillai's trace, to test the effect of the interaction between the MSLQ and the groups. The results revealed no significant effect between the groups and the MSLQ grand totals, V=.026, F(3, 72) = .65, p =.59. Each test statistic was significant for the interaction between pretest and posttest grand totals of the MSLQ. Table G58, the test of within subject contrast, revealed a significant difference with the interaction between the MSLQ pretest grand totals and MSLQ posttest grand totals,

$F(1,72) = 5.14$, $p = .03$. But the interaction between the MSLQ grand totals and the groups revealed no significant effect, $F(3,72) = 1.10$, $p = .35$. In Table G59, the test between the groups revealed no statistical significance. In Table G60, the interaction between the control group and the other groups were contrasted. The results of Table G60 revealed no significance contrast between the control group and the other groups. In Table G61, Fisher's Least Significant difference, I analyzed multiple comparisons between every group. The results in Table G61, revealed that there was no significant effect between any statistic and the group type. Figure 2 gives a visual representation of the marginal means across the groups between the pretest grand totals and the posttest grand totals.

In conclusion there were no statistical significance that supported any effects between the MSLQ and interaction with technology with the Paired Sample t-test or the Factorial Repeated ANOVA. So the null hypotheses could not be rejected for the following research questions and alternative hypotheses:

- **Research Question1.** "Does interactive technology, the TI Nspire calculators, provide the stimulus or "action" needed to increase students' motivation and interest in the mathematical classroom?"

  $H_1$1 - There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators.

- **Research Question 2**. "Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or "action" needed to increase students' motivation and interest in the mathematical classroom?"

$H_1$2. There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator.

- **Research Question 3**. "Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' motivation and interest in the mathematical classroom?"

  $H_1$3 There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators, the TI navigator and the clickers.

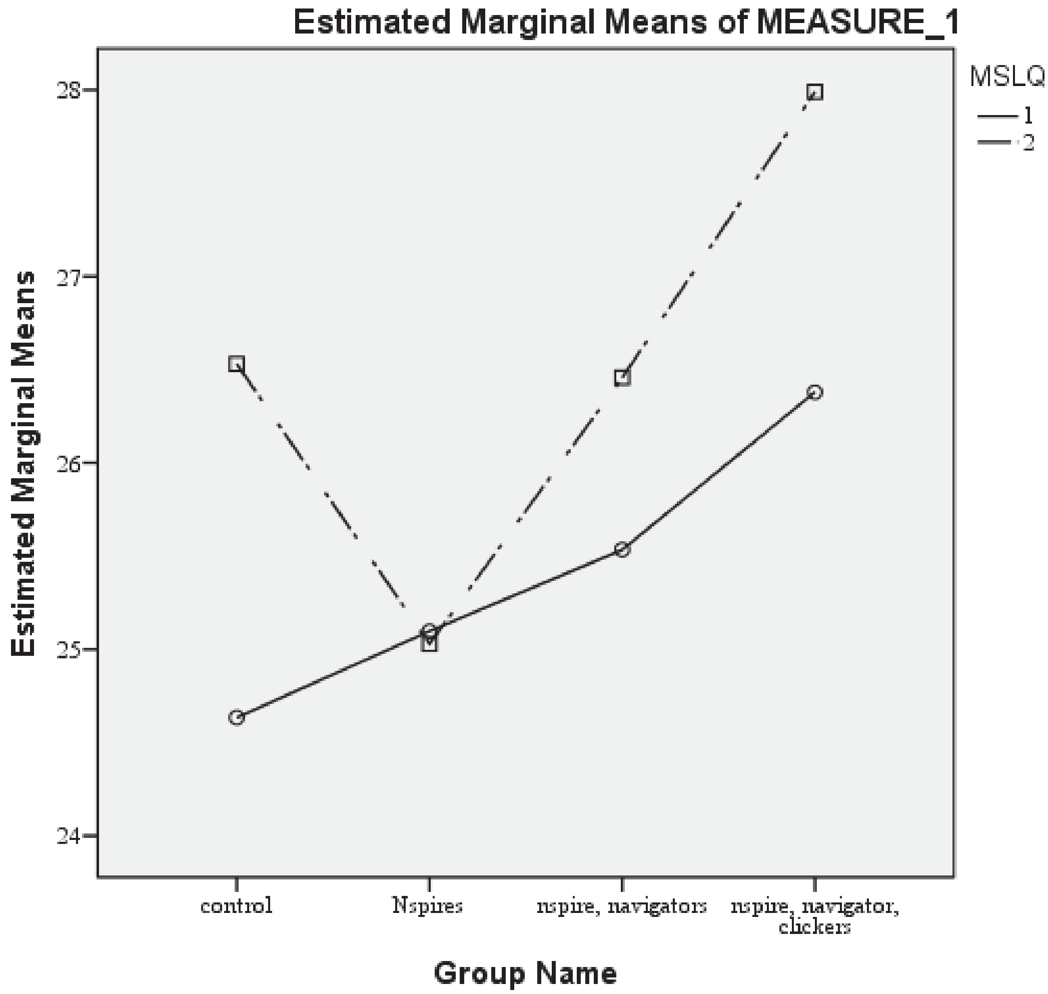


Figure 2 MSLQ Pre and Post Means across groups.

STAAR – Research Questions

In this section, I analyzed the last three research questions and their related hypotheses using the results displayed in Tables H62 through H72 and Figure 3. In Table H62 and Table H63, the subject factors are identified. Table H62, the "within subject factors" compared the grand totals effects within the pre-STAAR and the post-STAAR. Table H63, the "between subject factors" compared the effects between each group. In Table H64, general statistics like the mean and standard deviation are given for each group pretest and posttest. The mean values in Groups 1 and Group 2 were the highest in the groups while the mean values of Groups 3 and 4 were relatively close. On the posttest all of the groups' means and standard deviation were relatively close to each other. However Groups 3 and 4, the groups using the most technology, had a double digit increase in their means from the pretest to the posttest. In Table H65, the Box's test of equality of the covariance matrix was not significant. The Box's Test statistic tested whether the null hypothesis of the observed covariance matrices of the dependent variable are equal across groups. The Box's test statistic can be ignored if the sample sizes are equal. The sample sizes in this study are relatively equal (sample sizes - 21, 17, 20 and 18). So the results of the Box's test statistic was ignored. In Table H66, the Mauchly test of sphericity, no significant value is given in the Table, that column has a blank value. If a repeated measure variable has only 2 levels the sphericity is always met. This means that the differences between treatments or experimental conditions and between each pair of scores are approximately equal. In Table H67, the multivariate test (MANOVA), the results of 4 test statistics (Pillai's Trace, Wilks's Lambda, Hotelling's

Trace and Roy's Largest Root) were given. The MANOVA, tested the differences between groups across several dependent variables. In Table H67, the interaction between the pretest and the posttest grand totals revealed a significant effect for all test statistics. Using Pillai's trace to test the effect of the STAAR grand totals, there was a significant effect from the treatment between the STAAR grand totals from the pretest to the posttest, V=.465, F(1,72)=62.64, p <.05. Using Pillai's trace to test the effect of the interaction between the STAAR and each group, showed a significant effect between the groups of the STAAR grand totals, V=.126, F(3, 72) = 3.45, p =.02. Each test statistic was significant for the interaction between the groups and the STAAR grand totals. In Table H68, test of within subjects' effects, a significant difference between the interaction of the pretest and the posttest grand totals was revealed. The results for all of the effects show the same, F (1, 76) = 62.64, p<.05. Also in Table H68, there is a significant difference between the interaction of the STAAR pretest and the posttest within the groups for all of the effects. The results for all of the effects also show the same, F (3, 72) =3.45, p =.02. In Table H69, Within Subject Contrast, the interaction between the STAAR pretest and posttest reveals a significant difference in the effect or treatment, F(1,72) = 62.64, p>.05. Also the interaction between the STAAR (pretest and posttest grand totals) and the groups revealed a significant effect, F(3,72) = 3.45, p=.02, In Table H70, the test between the groups revealed no significance with the treatment groups. In Table H71, the interaction between the control group and the other groups were contrasted. The results of Table H71 revealed no significance contrast between the control group and the other groups. In Table H72 using Fisher's Least Significant difference, I analyzed multiple comparisons between every group. The results in Table H72, revealed that there were no significant effect between any statistic and the group type. Figure 3 gives a visual representation of the marginal means across the groups. On the graph you can see the difference between the pretest and posttest grand totals for each group. The largest gaps are between groups 3 and 4. These are the groups using 2 or more interactive technologies.

Finally, I analyzed the grand total scores for the STAAR, using a repeated factorial ANOVA. The results revealed a statistical significance between the STAAR pretest grand totals and the STAAR posttest grand totals. I synthesized the results from the Paired Sample t-test and the Factorial repeated ANOVA. That synthesis revealed the following results for each research question and their alternative hypotheses:

In research question 4 and hypothesis 4, restated below, the null hypothesis could not be rejected for treatment Group 2, the group using the TI Nspire calculator only.

- **Research Question 4**. “Does interactive technology, the TI Nspire calculators, provide the stimulus or “action” needed to improve students’ test scores?

  $H_1$4. There is a significant increase in students’ test scores when using the TI Nspire calculators.

In research question 5 and hypothesis 5, restated below, the null was rejected and the alternative hypothesis is true for Group 4, the group using 2 types of interactive technology.

- **Research Question 5.** Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or “action” needed to improve students’ test scores?

  $H_1$5. There is a significant increase in students’ test scores when using the TI Nspire calculators with the TI navigator.

In research question 6 and hypothesis 6, the null was rejected and so the alternative hypotheses, stated below is true. This is Group 4, the group using 3 types of interactive technology.

- **Research Question 6**. Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or “action” needed to improve students’ test scores?

  $H_1$6. There is a significant increase in students’ test scores when using the TI Nspire calculators with the TI navigator and the clicker technology.

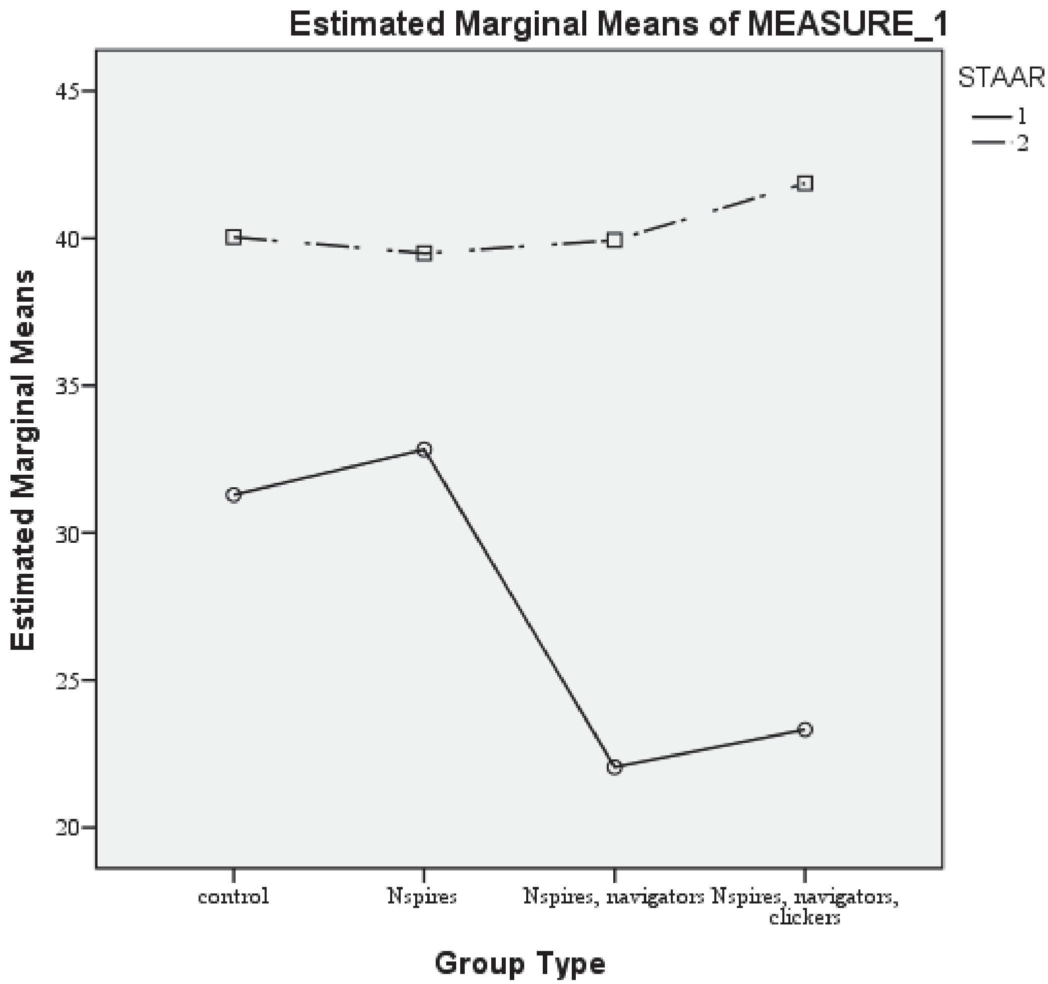


Figure 3: STAAR Pre-Post Means Across Groups

Summary and Conclusion

In this study, six research questions were analyzed using SPSS. Those research questions were measured using the pre and post results from a questionnaire, the Motivational Strategy for Learning Questionnaire (MSLQ), and a state test called the State of Texas Assessment of Academic Readiness (STAAR). There were three treatment groups and one control group. The control group, Group 1 did not have access to any of the technology given to the treatment group. The Statistical Package for Social Science (SPSS) analyzed the data. The paired *t* test or dependent *t* test and the factorial repeated ANOVA analyzed the significance within the groups, between the groups, and compared to the control group. There were some significant effects within each group in some categories. Even the control group that used no technology displayed some significance in some categories on the MSLQ and the STAAR. But when the total scores for each student was computed and each assessment analyzed (the MSLQ and the STAAR) as a complete unit, there was no statistical significance from the use of technology with any of the treatment groups for the MSLQ. There was a significant difference in the pre to the posttest for the STAAR for Groups 3 and 4. In Chapter 5, this study summarized, made conclusions and recommendations for further research.

Chapter 5: Summary, Recommendations, and Conclusions

Introduction

In this chapter, I discuss the following areas: (a) A summary of the study, (b) a discussion of the findings, (c) implications for practice, (d) recommendations for further research, and (e) the conclusion. In the summary, I briefly restate: (a) the problem, (b) the purpose, (c) the theoretical framework, (d) the research questions, (e) the alternative hypothesis, (f) the methodology, and (g) the findings from Chapter 4. In the discussion of the findings section, I also discuss the relationships between the theoretical framework, the literature review, and the findings in this study. In the implications for practice section, I examine any relationship between my study and the practical application of the. In the recommendations for further research, I make suggestions on how to improve this study or extend this study for further research. Finally the conclusion provided closure to this research study by summarizing any statistical issues that supported my study or failed to support my study.

Summary of the Study

This study was initiated from the ongoing reports about the United States students low math scores. In a review of the literature Grimes and Warschauer (2008) stated:

> The reading and mathematics test scores at the high school level are no higher now than they were 30 years ago (National Assessment of Educational Progress, 2005), inquiry-based learning is declining in schools due to pressures of standardized testing, and the U.S. workforce remains woefully under-prepared. (p. 305)

Hossain and Robinson (2011) stated that, “science and technology had been powerful engines of prosperity in the United States since World War II but, currently science, technology and mathematics education as well as the capability of the American workforce are in decline” (p.1). Bybee and Stage, (2005) stated that, “our teens are among the worse at math in the world” (p.69). Aud and Hannes (2011), in their article for the National Center for Education Statistics, confirmed that the current condition of the educational system had improved by a few points on the national level but was still below standards on the international level (p.6). Those quotes were only a few of the many statistics about the math education in the United States. This concern about the mathematical education led to my quest to contribute to the knowledge base that would inform mathematical teaching on a local, state and national level. Because of this, the study would have a dual impact on mathematics teaching. The first purpose of this study focused on a technological impact on students’ math scores while the secondary purpose of this study focused on a social impact by analyzing students’ motivation when they are experiencing technology.

The theoretical base of this study was formed from a constructivist perspective. Theorist like Jean Piaget and Seymour Papert formed the foundation for this study. Current views by the National Council of Teachers of Mathematics (NCTM) conference also provided an important analysis for the use of technology in this 21st century educational system.

Piaget (1970) confirmed that action is the key to accessing the intelligence of children (pp.28-20). This action must be the stimuli that would force children to build physical and mental models during the construction or invention of knowledge. These mental models would be permanent memory component to be used for future recollection of math concepts and skills. Papert (1980), a proud advocate of the Piagetian theories, used his knowledge of mathematics with computers to help children focused on their own thinking processes (p.5). According to Papert (1980), when a child thinks about his or her thinking processes the child become an epistemologist, an experience not even shared by most adults (p. 19). Finally, the National Council of Teachers of Mathematics (NCTM) verified the importance of technology as an intellectual building tool in the mathematical classroom.

My research questions and hypotheses were:

- **Research Question1.** “Does interactive technology, the TI Nspire calculators, provide the stimulus or “action” needed to increase students’ motivation and interest in the mathematics classroom?”
    - **Hypotheses 1** - There is a significant increase in students’ motivation toward learning mathematics when using the TI Nspire calculators.
- **Research Question 2**. “Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or “action” needed to increase students’ motivation and interest in the mathematical classroom?”
    - **Hypotheses 2**. There is a significant increase in students’ motivation toward learning mathematics when using the TI Nspire calculators with the TI navigator.

- **Research Question 3**. "Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' motivation and interest in the mathematical classroom?"
    - **Hypotheses 3**. There is a significant increase in students' motivation toward learning mathematics when using the TI Nspire calculators, the TI navigator and the clickers.
- **Research Question 4**. "Does interactive technology, the TI Nspire calculators, provide the stimulus or "action" needed to improve students' test scores?
    - **Hypotheses 4.** There is a significant increase in students' test scores when using the TI Nspire calculators.
- **Research Question 5.** Does interactive technology, TI Nspire calculators with the TI Navigator, provide the stimulus or "action" needed to improve students' test scores?
    - **Hypotheses 5.** There is a significant increase in students' test scores when using the TI Nspire calculators with the TI navigator.
- **Research Question 6**. Does interactive technology, TI Nspire calculators with the TI Navigator and clickers, provide the stimulus or "action" needed to improve students' test scores?
    - **Hypotheses 6.** There is a significant increase in students' test scores when using the TI Nspire calculators with the TI navigator and the clicker technology.

A quantitative quasi-experimental design was used to get a broader perspective of the use of interactive technology on test scores. This quantitative design revealed, statistically, any comparisons or correlations in the data between motivation, test scores, and interactive technology. The Statistical Package for Social Science (SPSS) was used to run a paired samples *t* test where I analyzed the categorical data from the MSLQ and the STAAR and, using a factorial repeated ANOVA, I analyzed the grand total scores of the MSLQ and the STAAR. The results of that methodology revealed no significant effect of technology related to the MSLQ but the STAAR revealed a statistical significance with Group 3 and Group 4.

Discussion of the Findings

The results of my study indicated that the Piagetian theory that action, in an educational setting, is the gateway to the acquisition of knowledge and intelligence. Piaget stated the following: "the acquisition of knowledge or intelligence is derived from actions, not in the sense of simple associative responses, but in the much deeper sense of the assimilation of reality into the necessary and general coordination of actions" (Piaget, 1970, pp. 28-29). Piaget separated knowledge into three types: (a) physical knowledge (known as the discovery stage), (b) logical mathematical knowledge (known as the invention stage), and (c) social knowledge (known as the social interactive stage; Piaget 1977 as cited in Wadsworth, 1996, p.23). The students' engagement with the interactive technology allowed them to manipulate all three types of knowledge. Physical knowledge (known as the discovery stage) was engaged when the students explored various algebraic concepts and skills in the mathematical environment with the technology. The students were able to assemble ideas that were viewed from their calculators. This allowed the teacher the ability to reteach immediately, which improved the students understanding of the mathematical concepts immediately. Logical mathematical knowledge (known as the invention stage) was engaged when the students had to predict real life problem situations based on their understanding of the concepts and skills learned in the mathematical environment. Social knowledge (known as the social interactive stage) was triggered when the students worked in groups during group projects related to the STAAR. These Piagetian theories formed the major framework of this study. Papert and the National Council of Teachers of Mathematics were minor contributors that solidified the need for technology in the mathematical environment for the 21st century and beyond.

The finding in this study contributed to the literature on technological studies in mathematical learning. My study was specific to the State of Texas Assessment of Academic Readiness test (STAAR). In the literature review section on technological research in mathematics, the research treatment group utilized one type of technology, mainly the calculator. In my study, the group with just the use of the Nspire calculator (one type of interactive technology) displayed results that were less significant than the groups who used two or three types of interactive technology. In the literature review, research study that where the researchers described the use of more than one type of technology, the researcher stated that, “Technical understanding was observed by the students’ using routine steps during basic computations, defining mathematical basis of commands and syntax, and defining actions to assist them in their interpretation of graphs" (Forster, 2006, p. 160). That study did not record or compare any pretest data and no control group was utilized. None of the literature review studies used the comparison of the MSLQ, the state test, and technology. In the literature, I found significant results using one type of technology. In my study, I demonstrated statistical significant with students who used more than one type of technology. This discrepancy could have been related to the fact that 21st century students are more techno savvy and require more interactions with various technology to stimulate them.

Implications and Recommendations

Implications

I contribute to the current research on using technology in the mathematics classroom, but my study is specific to state assessment using pre and posttest, as well as a control group. The results from using more than one type of technology enabled teachers of mathematics to explore more technology instead of using just the traditional calculator. The TI Nspire is more than just a calculator. If the Nspire is used with the navigational system, it allows the teacher to view each student's calculator keystrokes and results. This would allow the students to receive immediate corrections to adjust their performance.

The Nspire also functions in much the same way as Microsoft Word and Microsoft Excel. The students can create and use documents and create and use spreadsheets. The functional use of the applications are also the same as the functional on Microsoft Word and Excel. The e-Instruction clickers is another interactive piece of technology that gives immediate feedback to the teacher and to the students.

Recommendations

Technology in the classroom is becoming a norm. The mathematics classroom, at the secondary level, as always had the ability to use the calculator but additional technology wasn't required. In the National Assessment of Educational Progress (NAEP), in the article "The Condition of Education 2013," researchers assessed students' performance in mathematics at Grades 4, 8, and 12, and found:

> From 1990 to 2011, the average 4th-grade NAEP mathematics score increased by 28 points, from 213 to 241. The average 8th-grade score increased by 21 points, from 263 to 284. The Twelfth-graders, who were recently assessed in 2009; in that year, the average 12th-grade mathematics score was 3 points higher than in 2005. (Aud & Hannes, 2013, p. 104)

For a secondary grade level to only show three points improvement over the cthese of 4 years is an example of the mathematics state of the country that necessitates the immediate attention. Providing students with as many technology tools to assist their understanding of mathematical concepts and skills could only help the students and help the nation compete with other nations in the areas of mathematics and engineering. If more researchers focused on improvements in mathematics using technology, then the local, state, and national government might be persuaded to provide funding for more technology or diverse technology in the mathematics classroom.

Conclusion

Issues or Conflicts

This study started late in the school year and the desired start time was the beginning of the school year. The problem with the starting time of the study was that the students had already been exposed with some of the Algebra I curriculum before the pretest. The students in the control group also had prior knowledge of using calculators to solve some of the math problems and did not adjust well to using only paper and pencil methods.

The experience levels of the teachers involved in this study ranged from 15 years of experience to 3 years of experience. The teachers with the most experience were teaching the control classes and the teachers with the least experience were teaching the classes with technology. Also the teaching styles of the teachers were very diverse. Some teachers taught more traditionally, blackboard and lecture, while others were more progressive, mini lessons then small group collaboration. These discrepancies may have affected the results of the MSLQ and the STAAR. There were categories in the STAAR that produced significant improvement with the control group.

Another conflict was the continuous absences of the students that made it impossible to assess them with any type of accuracy because they were constantly absent from class or removed from class for behavior issues. Those students' data had to be removed, because they did not complete all areas of this study. The absences also contributed to my sample size being smaller than expected.

Conclusion and Summary

In this study, it was initially assumed that there would be a statistical significance with the MSLQ and the STAAR. The statistical significance did not materialize with the MSLQ with any of the groups. This condition could be totally true or the results could be related to the experience level of the teachers or the length of time given to this study. The results for the STAAR revealed a statistical significance for the treatment groups using two or more types of technologies. The group that only used the TI Nspire had almost the same results as the control group in most of the categories. This could have been caused by the fact that calculators are a norm for the mathematics classrooms now. Also the students in the control group and Group 1 had some prior experience with calculators in a mathematics classroom. Longevity studies with various interactive technologies and state required testing should be explored to compare my short term study with a longevity study of the same type.

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Appendix A

Assessment 1: Motivation Survey Tool

Student ID# ______________________________ Date: __________________

Motivation Profile

The following questions ask about your motivation for and attitudes about this class. There is no right or wrong answers, just answer as accurately as possible. Use the scale below to answer the questions. If you think the statement is very true of you, circle 7; if a statement is not at all true of you circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
Not at all True of me						very true of me

1. In a class like this, I prefer course material that really challenges me so I can learn new things.	1 2 3 4 5 6 7
2. If I study in appropriate ways, then I will be able to learn the material in this course.	1 2 3 4 5 6 7
3. When I take a test I think about how poorly I am doing compared with other students.	1 2 3 4 5 6 7
4. I think I will be able to use what I learn in this course in other courses.	1 2 3 4 5 6 7
5. I believe I will receive an excellent grade in this class.	1 2 3 4 5 6 7
6. I'm certain I can understand the most difficult material presented in the readings for this course.	1 2 3 4 5 6 7
7. Getting a good grade in this class is the most satisfying thing for me right now.	1 2 3 4 5 6 7

8. I When I take a test I think about items on other parts of the test I can't answer. 1 2 3 4 5 6 7

9. It is my own fault if I don't learn the material in this course. 1 2 3 4 5 6 7

10. It is important for me to learn the course material in this class. 1 2 3 4 5 6 7

11. The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade. 1 2 3 4 5 6 7

12. I'm confident I can learn the basic concepts taught in this course. 1 2 3 4 5 6 7

13. If I can, I want to get better grades in this class than most of the other students. 1 2 3 4 5 6 7

14. When I take tests I think of the consequences of failing. 1 2 3 4 5 6 7

15. I'm confident I can understand the most complex material presented by the instructor in this course. 1 2 3 4 5 6 7

16. In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn. 1 2 3 4 5 6 7

17. I am very interested in the content area of this course. 1 2 3 4 5 6 7

18. If I try hard enough, then I will understand the course material. 1 2 3 4 5 6 7

19. I have an uneasy, upset feeling when I take an exam. 1 2 3 4 5 6 7

20. I'm confident I can do an excellent job on the assignments and tests in this course.	1 2 3 4 5 6 7
21. I expect to do well in this class.	1 2 3 4 5 6 7
22. The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	1 2 3 4 5 6 7
23. I think the course material in this class is useful for me to learn	1 2 3 4 5 6 7
24. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.	1 2 3 4 5 6 7
25. If I don't understand the course material, it is because I didn't try hard enough.	1 2 3 4 5 6 7
26. I like the subject matter of this course.	1 2 3 4 5 6 7
27. Understanding the subject matter of this course is very important to me.	1 2 3 4 5 6 7
28. I feel my heart beating fast when I take an exam.	1 2 3 4 5 6 7
29. I'm certain I can master the skills being taught in this class.	1 2 3 4 5 6 7
30. I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.	1 2 3 4 5 6 7
31. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	1 2 3 4 5 6 7

Appendix B

Parent Consent Form for Research

Your child is invited to take part in a research study. Teachers of first-year Algebra 1 courses at our school have permission from the principal to try using different types of technology for 9 weeks to see if this will excite students to learn Algebra and improve the students' test scores in classroom assessments and on the State of Texas Assessment of Academic Readiness (STAAR). XXXXXXX is inviting students in these classes to volunteer to complete a survey and an extra practice math test (that will not count toward their grade) after school from 4:30pm to 5:30pm. She will be comparing the surveys and test scores from classrooms who use different tools in order to help make the best tools available to more students. This form is part of a process called "informed consent" to allow you to understand this study before deciding whether to allow your child to take part.

This study is being conducted by a researcher named XXXXXXXX, who is an Educational Technology doctoral student at Walden University. You may already know the researcher as a XXXXXXXX, but this study is separate from that role. Her role will **only** be to collect and analyze the data. This study is not being conducted by the district or school although results from this study will be shared with the school and district.

Background Information:
The purpose of this study is to investigate whether specific types of interactive technologies, TI Nspire calculators and clickers, can possibly have the following effects:

- Increase students' participation in the mathematics classroom.
- Increase students' performance on assessment test.

Procedures:
If you ***agree*** to allow your child to be in this study, your child will be asked to:

Complete two assessments taken together, a survey and a STAAR practice test. Both assessments will take 30 minutes each to complete and will be conducted after school from 4:30pm to 5:30pm. The two assessments will be given at the beginning of the 9 weeks period and at the end of the 9 weeks period.

The survey will ask your child various questions related to the following:

- His or her goals about learning mathematics,
- His or her study habits in the math classroom.

The STAAR practice test will contain questions like the STAAR test that your child took in the 8th grade, but at the 9th grade level.

If you ***do not agree*** for your child to be in this project, then your child will not be required to participate in the after school survey and assessment.

Here are some sample questions:

The survey sample question:

- In a class like this, I prefer course material that really challenges me so I can learn new things.

STAAR sample question:

- Cato went to eat at Zen's Pizza Parlor with some friends. He used a coupon which deducts c dollars from the original cost of the pizza. Cato's meal cost $11.60, and he left a tip of 15% of the original cost of the pizza for the waiter. He used this equation to find T, the amount of the tip. T = .15(11.60 + c. If the coupon was for $5 off, how much did he leave as a tip?

Voluntary Nature of the Study:
This study is voluntary. Everyone will respect your decision as to whether or not you want your child to be in the study. If you decide to consent now, you or your child can still change your mind later.

Risks and Benefits of Being in the Study:
There are no risks involved in this study.
The study could result in helping us make the technology available for more students if we can show that the technology boosts students' motivation and test scores.

Compensation
Your child **will not** receive any monetary benefits for being in this study.

Privacy
Your identity in this study will be kept private. I will not share your responses or your name with anyone. Data will be kept for a period of 5 years, as required by the university.

Contacts and Questions: You may ask any questions you have about the study by contacting me via email or telephone XXXXXXXXXXXXXXX or the University's Research Participant Advocate at XXXXXXXXX, extension XXXX, or email address XXXXXXXX.

Walden University's approval number for this study is **04-03-13-0024044** and it expires on **January 7, 2014.**

Statement of Consent:

I have read the above information and I feel I understand the study well enough to make a decision about my child's involvement this optional research project. By signing below, I understand that I am agreeing to the terms described above.

Contacts and Questions: You may ask any questions you have about the study by contacting me via email or telephone: XXXXXXXXX or the University's Research Participant Advocate at XXXXXXXX or email address XXXXXXXX.

Walden University's approval number for this study is **04-03-13-0024044** and it expires on **January 7, 2014.**

I will give you a copy of this form.

____

Printed Name of Parent

____

Printed Name of Child

____

Date of consent

____

Parent's signature

____

Researcher's signature / date

Assent form for Research

Hello, my name is XXXXXXXX and I am doing a research project to learn whether using different types of technology might increase students' desire to participate in an Algebra1 classroom and improve students' test scores on the State of Texas Assessment of Academic Readiness (STAAR). I am inviting you to join my project. I am only inviting students that are enrolled in an Algebra 1 class. This study will be administered after school from 4:30pm to 5:30pm in the cafeteria. I am going to read this form with/to you. I want you to learn about the project before you decide if you want to be in it.

WHO I AM:
I am a student at Walden University. I am working on my doctoral degree. You may already know me as a math teacher, but this study is separate from that role.

ABOUT THE PROJECT:
If you ***agree*** to be in this project, you will be asked to:

Complete two assessments taken together, a survey and a STAAR practice test. Both assessments will take 30 minutes each to complete and will be conducted after school from 4:30pm to 5:30pm. The two assessments will be given at the beginning of the 9 weeks period and at the end of the 9 weeks period.

The survey will ask you various questions related to the following:

- Your goals about learning mathematics,
- And your study habit in a mathematics class.

The STAAR practice test will contain questions like the STAAR test that you took in the 8th grade.

If you ***do not agree*** to be in this project, you will not be required to participate in the after school survey and assessment.

Here are some sample questions:

The survey sample question:

- In a class like this, I prefer course material that really challenges me so I can learn new things.

STAAR sample question:

- Cato went to eat at Zen's Pizza Parlor with some friends. He used a coupon which deducts c dollars from the original cost of the pizza. Cato's meal cost $11.60, and he left a tip of 15% of the original cost of the pizza for the waiter. He used this equation to find T, the amount of the tip. T = .15(11.60 + c. If the coupon was for $5 off, how much did he leave as a tip?

IT'S YOUR CHOICE:
You don't have to be in this project if you don't want to. If you decide now that you want to join the project~~,~~ you can still change your mind later. If you want to stop, you can.

Being in this study would not pose any risk to your safety or well-being.
But we are hoping this project might help others by showing whether interactive technology will increase student test scores and motivation.

Compensation
You **will not** receive any monetary benefits for being in this study.

PRIVACY:
Your identity in this study will be kept private. I will not share your responses or your name with anyone.

ASKING QUESTIONS:
You can ask me any questions you want now. If you think of a question later, you or your parents can reach me at XXXXXXXX or email me at XXXXXXXX. If you or your parents would like to ask my university a question, you can call XXXXXXX. Her phone number is XXXXXXX, then dial XXXXXX.

Walden University's approval number for this study is **04-03-13-0024044** and it expires on **January 7, 2014.**

I will give you a copy of this form.

***Please sign your name below if you want to join this project*.**

____

Name of Child

____

Child signature

____

Date

____

Researcher's signature / date

Walden University's approval number for this study is **04-03-13-0024044** and it expires on **January 7, 2014.**

Appendix C

Data Collection Document #1

Motivation Pre/Post Results

Components/goals	Pretest/group results	Posttest/ group results
Value component		
Intrinsic goals *Questions: 1,16,22,24*		
Extrinsic goals *Questions: 7, 11,13,30*		
Task value *Questions: 4,10,17,23,26,27*		
Expectancy component		
Control of learning beliefs *Questions: 2,9,18,25*		
Self-efficacy for learning *Questions: 5,6,12,15,20,21,29,31*		
Affective component *Questions: 3,8,14,19,28*		

Appendix D

Data Collection Document #2

STAAR Pre/Post Results – Readiness Skills

Reporting Category	Pre Test	Post Test
Functional relationships A.1D – questions: 1,20,21 A.1E – questions:2,9,19		
Properties and attributes of functions A.2.B – question: 6,7,8 A.2.D – question:3,4,5 A.4.A – questions:10,17,18		
Linear functions A.5.C – questions: 14,15,16 A.6.B – questions: 11,12,13 A.6.C – questions: 37,38,39 A.6.F– questions:34,35,36		
Linear equations and inequalities A.7.B – questions: 31,32,33 A.8.B – questions:28,29,30		
Quadratics and other nonlinear functions A.9.D – questions: 25,26,27 A.10.A – Questions: 22,23,24		

Appendix E

MSLQ Tables – Paired Sample T-test

Table 11

MSLQ Paired Sample Statistics Category 1 by Group

Group/goal	Mean	N	Std. deviation	Std. Error mean
1-Pre intrinsic goals	18.81	21	5.01	1.09
1-Post intrinsic goals	20.81	21	4.48	0.98
2-Pre intrinsic goals	19.88	17	4.5	1.09
2-Post intrinsic goals	20.24	17	4.83	1.17
3-Pre intrinsic goals	19.65	20	4.28	0.96
3-Post intrinsic goals	20.6	20	4.87	1.09
4-Pre intrinsic goals	19.56	18	4	0.94
4-Post intrinsic goals	21.06	18	4.07	0.96

Table 12

MSLQ Pearson Paired Sample Correlations Category 1 by Group

Group/goals	N	Correlation	Sig.
1-Pre intrinsic goals & 1-Post intrinsic goals	21	.02	.94
2-Pre intrinsic goals & 2-Post intrinsic goals	17	.81	.00
3-Pre intrinsic goals & 3-Post intrinsic goals	20	-.10	.67
4-Pre intrinsic goals & 4-Post intrinsic goals	18	.32	.20

Table 13

MSLQ Paired Sample T-test Category 1 by Group

	Paired Differences							
				95% Confidence interval of the difference				
Group/goal	Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre intrinsic goals - 1-Post intrinsic goals	-2.00	6.66	1.45	-5.03	1.03	-1.38	20	.18
2-Pre intrinsic Goals - 2-Post intrinsic Goals	-0.35	2.89	0.70	-1.84	1.13	-0.50	16	.62
3-Pre intrinsic Goals - 3-Post intrinsic Goals	-0.95	6.81	1.52	-4.14	2.24	-0.62	19	.54
4-Pre intrinsic Goals - 4-Post intrinsic Goals	-1.50	4.72	1.11	-3.85	0.85	-1.35	17	.20

Table 14

MSLQ Paired Statistics Category 2 by Group

Groups/goals	mean	N	Std. deviation	Std. error mean
1 Pre extrinsic goals	23.10	21	4.45	.97
1 Post extrinsic goals	24.10	21	3.74	.82
2 Pre extrinsic goals	23.76	17	4.58	1.11
2 Post extrinsic goals	23.00	17	4.21	1.02
3 Pre- Extrinsic Goals	24.05	20	3.46	.77
3 Post-Extrinsic Goals	24.35	20	3.00	.67
4 Pre extrinsic goals	24.72	18	3.72	.88
4 Post extrinsic goals	28.22	18	17.02	4.01

Table 15

MSLQ Paired Sample T-test Category 2 by Group

Groups/goals	N	Correlation	Sig.
1-Pre extrinsic goals & 1-Post extrinsic goals	21	.18	.44
2-Pre extrinsic goals & 2-Post extrinsic goals	17	.73	.00
3-Pre extrinsic goals & 3-Post extrinsic goals	20	.01	.97
4-Pre extrinsic goals & 4-Post extrinsic goals	18	.27	.27

Table 16

MSLQ Paired Sample T-test Category 2 by Group

Groups/ goals	Paired differences Mean	Std. deviation	Std. error mean	95% Confidence interval of the difference Lower	Upper	t	df	Sig. (2-tailed)
1-Pre extrinsic goals - 1-Post extrinsic goals	-1.00	5.27	1.15	-3.40	1.40	-0.87	20	.40
2-Pre extrinsic goals - 2-Post extrinsic goals	0.76	3.23	0.78	-0.90	2.43	0.98	16	.34
3-Pre extrinsic goals - 3-Post extrinsic goals	-0.30	4.55	1.02	-2.43	1.83	-0.29	19	.77
4-Pre extrinsic goals - 4-Post extrinsic goals	-3.50	16.40	3.87	-11.66	4.66	-0.91	17	.38

Table 17

MSLQ Paired Statistics Category 3 by Group

Groups/goals	Mean	N	Std. Deviation	Std. Error Mean
1 Pre task value	29.33	21	8.05	1.76
1 Post task value	29.57	21	6.57	1.43
2 Pre task value	30.06	17	7.84	1.90
2 Post task value	29.00	17	7.30	1.77
3 Pre task value	30.35	20	5.23	1.17
3 Post task value	30.80	20	4.81	1.08
4 Pre task value	30.78	18	4.51	1.06
4 Post task value	32.83	18	5.54	1.31

Table 18

MSLQ Pearson Correlations Category 3 by Group

Group/goals	N	Correlation	Sig.
1-Pre task value & 1-Post task value	21	.14	.54
2-Pre task value & 2-Post task value	17	.60	.01
3-Pre task value & 3-Post task value	20	.44	.05
4-Pre task value & 4-Post task value	18	-.13	.60

Table 19

MSLQ Paired Sample T-test Category 3 by Group

	Paired differences							
				95% Confidence interval of the difference				
Group/goal	Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre task value - 1-Post task value	-.24	9.64	2.10	-4.63	4.15	-.11	20	.91
2-Pre task value - 2-Post task value	1.06	6.81	1.65	-2.44	4.56	.64	16	.53
3-Pre task value - 3-Post task value	-.45	5.33	1.19	-2.94	2.04	-.38	19	.71
4-Pre task value - 4-Post task value	-2.06	7.59	1.79	-5.83	1.72	-1.15	17	.27

Table 20

MSLQ Paired Statistics Category 4 by Group

Groups/goals	Mean	N	Std. deviation	Std. error mean
1-Pre control of learning behavior	19.52	21	5.02	1.10
1-Post control of learning behavior	22.57	21	2.64	0.58
2-Pre control of learning behavior	20.12	17	4.72	1.14
2-Post control of learning behavior	20.18	17	4.73	1.15
3-Pre control of learning behavior	20.70	20	4.96	1.11
3-Post control of learning behavior	21.25	20	3.96	0.89
4-Pre control of learning behavior	21.89	18	3.85	0.9
4-Post control of learning behavior	23.00	18	3.38	0.80

Table 21

MSLQ Pearson Correlations Category 4 by Group

Groups/goals	N	Correlation	Sig.
1-Pre control of learning behavior & 1-Post control of learning behavior	21	.37	.10
2-Pre control of learning behavior & 2-Post control of learning behavior	17	.69	.00
3-Pre control of learning behavior & 3-Post control of learning behavior	20	.45	.05
4-Pre control of learning behavior & 4-Post control of learning behavior	18	.05	.84

Table 22

MSLQ Paired Sample T-test Category 4 by Group

	Paired Differences							
				95% Confidence Interval of the Difference				
Groups/goals	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre control of learning behavior 1-Post control of learning behavior	-3.05	4.73	1.03	-5.20	-0.90	-2.95	20	.01
2-Pre control of learning behavior 2-Post control of learning behavior	-0.06	3.72	0.90	-1.97	1.85	-0.07	16	.95
3-Pre control of learning behavior 3-Post control of learning behavior	-0.55	4.77	1.07	-2.78	1.68	-0.52	19	.61
4-Pre control of learning behavior 4-Post control of learning behavior	-1.11	4.99	1.18	-3.59	1.37	-0.94	17	.36

Table 23

MSLQ Paired Statistics Category 5 by Group

Groups/goals	Mean	N	Std. Deviation	Std. Error Mean
1-Pre self-efficacy for learning	34.90	21	7.76	1.69
1-Post self-efficacy for learning	35.57	21	6.28	1.37
2-Pre self-efficacy for learning	34.65	17	7.02	1.70
2-Post self-efficacy for learning	36.12	17	7.41	1.80
3-Pre self-efficacy for learning	34.40	20	6.65	1.49
3-Post self-efficacy for learning	35.95	20	7.30	1.63
4-Pre self-efficacy for learning	37.06	18	6.40	1.51
4-Post self-efficacy for learning	37.50	18	5.81	1.37

Table 24

MSLQ Pearson Correlations Category 5 by Group

Groups/goals	N	Correlation	Sig.
1-Pre self-efficacy for learning & 1-Post self-efficacy for learning	21	.48	.03
2-Pre self-efficacy for learning & 2-Post self-efficacy for learning	17	.73	.00
3-Pre self-efficacy for learning & 3-Post self-efficacy for learning	20	.47	.04
4-Pre self-efficacy for learning & 4-Post self-efficacy for learning	18	.52	.03

Table 25

MSLQ Paired Sample Test Category 5 by Group

	Paired Differences							
				95% confidence interval of the difference				
Group/goals	Mean	Std. dev.	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre self-efficacy for learning 1-Post self-efficacy for learning	-.67	7.27	1.59	-3.98	2.64	-.42	20	.68
2-Pre self-efficacy for learning - 2-Post self-efficacy for learning	-1.47	5.30	1.29	-4.20	1.26	-1.14	16	.27
3-Pre self-efficacy for learning - 3-Post self-efficacy for learning	-1.55	7.19	1.61	-4.91	1.81	-.96	19	.35
4-Pre self-efficacy for learning - 4-Post self-efficacy for learning	-.44	5.98	1.41	-3.42	2.53	-.32	17	.76

Table 26

MSLQ Paired Statistics Category 6 by Group

Groups/goals	Mean	N	Std. deviation	Std. error mean
1-Pretest anxiety	22.14	21	6.15	1.34
1-Posttest anxiety	26.57	21	4.82	1.05
2-Pretest anxiety	22.12	17	6.24	1.51
2-Posttest anxiety	21.65	17	6.33	1.54
3-Pretest anxiety	24.05	20	4.37	0.98
3-Posttest anxiety	25.80	20	4.99	1.12
4-Pretest anxiety	24.28	18	5.22	1.23
4-Posttest anxiety	25.33	18	4.45	1.05

Table 27

MSLQ Pearson Correlations Category 6 by Group

	N	Correlation	Sig.
1-Pretest anxiety & 1-Posttest anxiety	21	.27	.23
2-Pretest anxiety & 2-Posttest anxiety	17	.57	.02
3-Pretest anxiety & 3-Posttest anxiety	20	.29	.21
4-Pretest anxiety & 4-Posttest anxiety	18	.17	.51

Table 28

MSLQ Paired Sample T-test Category 6 by Group

Test	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
				Lower	Upper			
1-Pretest anxiety - 1-Posttest anxiety	-4.43	6.70	1.46	-7.48	-1.38	-3.03	20	.01
2-Pretest anxiety - 2-Posttest anxiety	0.47	5.83	1.41	-2.53	3.47	0.33	16	.74
3-Pretest anxiety - 3-Posttest anxiety	-1.75	5.58	1.25	-4.36	0.86	-1.40	19	.18
4-Pretest anxiety - 4-Posttest anxiety	-1.06	6.26	1.48	-4.17	2.06	-0.71	17	.48

Table 29

MSLQ Total Statistics by Group

	1_Pre total	1_Post total	2_Pre total	2_Post total	3_Pre total	3_Post total	4_Pre total	4_Post total
Mean	24.63	26.53	25.10	25.03	25.53	26.46	26.38	27.99
Median	25.83	28.00	25.33	25.67	26.00	26.75	27.50	27.58
Mode	20[a]	28.00	21[a]	24[a]	28.00	18[a]	15[a]	26[a]
Std. deviation	5.01	3.91	5.10	5.30	3.64	4.01	3.93	5.07
Variance	25.10	15.28	26.01	28.06	13.22	16.10	15.46	25.73
Skewness	-0.55	-0.75	-0.54	-0.41	-1.03	-0.51	-1.73	1.61
Std. drror of skewness	0.50	0.50	0.55	0.55	0.51	0.51	0.54	0.54
Sum	517.3	557.1	426.6	425.4	510.6	529.15	474.8	503.8

a. Multiple modes exist. The smallest value is shown

Table 30

MSLQ Total Pearson Correlations by Group

Groups/Pre/posttest totals	N	Correlation	Sig.
1_Pre-totals & 1_Post-totals	21	.30	.18
2_Pre-totals & 2_Post-totals	17	.77	.00
3_Pre-totals & 3_Post-totals	20	.47	.04
4_Pre-totals & 4_Post-totals	18	.34	.17

Table 31

MSLQ Total Paired Sample T-Test by Group

	Paired Differences							
				95% Confidence Interval of the Difference				
Pre/post Test totals	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1_Pre-totals 1_Post-totals	-1.90	5.34	1.17	-4.33	0.53	-1.63	20	.12
2_Pre-totals 2_Post-totals	0.07	3.53	0.86	-1.75	1.89	0.08	16	.94
3_Pre-totals 3_Post-totals	-0.92	3.97	0.89	-2.78	0.93	-1.04	19	.31
4_Pre-totals 4_Post-totals	-1.61	5.26	1.24	-4.22	1.00	-1.30	17	.21

Appendix F

STAAR Tables – Paired Sample T-test

Table 32

STAAR Paired Statistics for Category 1 by Group

Groups/category	Mean	N	Std. Deviation	Std. Error Mean
1-Pre-category 1	32.53	21	20.05	4.38
1-Post-category 1	44.64	21	19.20	4.19
2-Pre-category 1	36.27	17	14.72	3.57
2-Post-category 1	42.65	17	22.99	5.58
3-Pre-category 1	24.99	20	20.60	4.61
3-Post-category 1	51.46	20	23.03	5.15
4-Pre-category 1	21.29	18	23.44	5.52
4-Post-category 1	45.14	18	16.12	3.80

Table 33

STAAR Pearson Correlations for Category 1 by Group

Groups/category	N	Correlation	Sig.
1-Pre-category 1 & 1-Post-category 1	21	-.07	.78
2-Pre-category 1 & 2-Post-category 1	17	.11	.69
3-Pre-category 1 & 3-Post-category 1	20	.14	.55
4-Pre-category 1 & 4-Post-category 1	18	.13	.61

Table 34

STAAR Paired Sample Test for Category 1 by Group

	Paired Differences							
				95% Confidence Interval of the Difference				
Groups/cat.	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre-category 1 - 1-Post-category 1	-12.11	28.65	6.25	-25.15	.93	-1.94	20	.07
2-Pre-category 1 - 2-Post-category 1	-6.38	25.95	6.29	-19.72	6.96	-1.01	16	.33
3-Pre-category 1 - 3-Post-category 1	-26.47	28.62	6.40	-39.86	-13.07	-4.13	19	.00
4-Pre-category 1 - 4-Post-category 1	-23.85	26.70	6.29	-37.12	-10.58	-3.79	17	.00

Table 35

STAAR Paired Statistics Category 2 by Group

Groups/category	Mean	N	Std. Deviation	Std. Error Mean
1-Pre-category 2	32.27	21.00	13.57	2.96
1-Post-category 2	35.71	21.00	19.03	4.15
2-Pre-category 2	35.28	17.00	16.78	4.07
2-Post-category 2	32.84	17.00	14.27	3.46
3-Pre-category 2	19.43	20.00	15.66	3.50
3-Post-category 2	40.83	20.00	18.29	4.09
4-Pre-category 2	16.66	18.00	18.77	4.42
4-Post-category 2	42.59	18.00	19.15	4.51

Table 36

STAAR Pearson Correlations for Category 2 by Group

Groups/category	N	Correlation	Sig.
1-Pre-category 2 & 1-Post-category 2	21.00	0.58	0.01
2-Pre-category 2 & 2-Post-category 2	17.00	0.10	0.70
3-Pre-category 2 & 3-Post-category 2	20.00	-0.04	0.88
4-Pre-category 2 & 4-Post-category 2	18.00	0.05	0.86

Table 37

STAAR Paired Sample T-test for Category 2 by Group

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre-category 2 1-Post-category 2	-3.44	15.64	3.41	-10.56	3.68	-1.01	20.00	0.32
2-Pre-category 2 2-Post-category 2	2.44	20.90	5.07	-8.30	13.19	0.48	16.00	0.64
3-Pre-category 2 3-Post-category 2	-21.40	24.50	5.48	-32.87	-9.93	-3.91	19.00	0.00
4-Pre-category 2 4-Post-category 2	-25.93	26.20	6.17	-38.96	-12.91	-4.20	17.00	0.00

Table 38

STAAR Paired Sample T-test for Category 3 by Group

Groups/category	Mean	N	Std. Deviation	Std. Error Mean
1-Pre-category 3	36.11	21.00	21.47	4.69
1-Post-category 3	41.59	21.00	15.90	3.47
2-Pre-category 3	38.73	17.00	21.45	5.20
2-Post-category 3	36.47	17.00	13.15	3.19
3-Pre-category 3	18.33	20.00	15.44	3.45
3-Post-category 3	35.33	20.00	16.49	3.69
4-Pre-category 3	26.85	18.00	21.11	4.98
4-Post-category 3	42.59	18.00	14.31	3.37

Table 39

STAAR Pearson Correlations for Category 3 by Group

Groups/category	N	Correlation	Sig.
1-Pre-category 3 & 1-Post-category 3	21.00	0.30	0.18
2-Pre-category 3 & 2-Post-category 3	17.00	0.23	0.37
3-Pre-category 3 & 3-Post-category 3	20.00	0.30	0.20
4-Pre-category 3 & 4-Post-category 3	18.00	0.13	0.59

Table 40

STAAR Paired Sample T-test for Category 3 by Group

	Paired Differences							
				95% Confidence Interval of the Difference				
Group/ category	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre-category 3 1-Post-category 3	-5.48	22.51	4.91	-15.72	4.77	-1.12	20.00	0.28
2-Pre-category 3 2-Post-category 3	2.26	22.41	5.43	-9.27	13.78	0.41	16.00	0.68
3-Pre-category 3 3-Post-category 3	-17.00	18.95	4.24	-25.87	-8.13	-4.01	19.00	0.00
4-Pre-category 3 4-Post-category 3	-15.75	23.86	5.62	-27.61	-3.88	-2.80	17.00	0.01

Table 41

STAAR Paired Statistics Category 4 by Group

Groups/category	Mean	N	Std. Deviation	Std. Error Mean
1-Pre-category 4	23.80	21.00	14.50	3.16
1-Post-category 4	38.57	21.00	21.75	4.75
2-Pre-category 4	26.46	17.00	20.46	4.96
2-Post-category 4	42.35	17.00	15.22	3.69
3-Pre-category 4	22.49	20.00	20.44	4.57
3-Post-category 4	31.25	20.00	17.31	3.87
4-Pre-category 4	19.43	18.00	18.30	4.31
4-Post-category 4	38.89	18.00	19.37	4.57

Table 42

STAAR Pearson Correlations for Category 4 by Group

Group/category	N	Correlation	Sig.
1-Pre-category 4 & 1-Post-category 4	21.00	0.19	0.40
2-Pre-category 4 & 2-Post-category 4	17.00	0.06	0.83
3-Pre-category 4 & 3-Post-category 4	20.00	0.05	0.82
4-Pre-category 4 & 4-Post-category 4	18.00	-0.21	0.40

Table 43

STAAR Paired Sample T-test for Category 4 by Group

Group/ category	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
1-Pre-category 4 1-Post-category 4	-14.77	23.70	5.17	-25.56	-3.99	-2.86	20.00	0.01
2-Pre-category 4 2-Post-category 4	-15.89	24.82	6.02	-28.65	-3.13	-2.64	16.00	0.02
3-Pre-category 4 3-Post-category 4	-8.76	26.08	5.83	-20.97	3.44	-1.50	19.00	0.15
4-Pre-category 4 4-Post-category 4	-19.46	29.33	6.91	-34.04	-4.87	-2.81	17.00	0.01

Table 44

STAAR Paired Statistics Category 5 by Group

Group/category	Mean	N	Std. Deviation	Std. Error Mean
1-Pre-category 5	31.74	21.00	14.82	3.23
1-Post-category 5	39.68	21.00	12.95	2.82
2-Pre-category 5	27.44	17.00	22.77	5.52
2-Post-category 5	43.14	17.00	15.16	3.68
3-Pre-category 5	25.00	20.00	24.49	5.48
3-Post-category 5	40.79	20.00	23.19	5.19
4-Pre-category 5	32.40	18.00	25.88	6.10
4-Post-category 5	40.12	18.00	15.31	3.61

Table 45

STAAR Pearson Correlations for Category 5 by Group

Group/category	N	Correlation	Sig.
1-Pre-category 5 & 1-Post-category 5	21.00	-0.04	0.86
2-Pre-category 5 & 2-Post-category 5	17.00	0.31	0.22
3-Pre-category 5 & 3-Post-category 5	20.00	0.41	0.07
4-Pre-category 5 & 4-Post-category 5	18.00	0.13	0.62

Table 46

STAAR Paired Sample T-test for Category 5

	Paired Differences							
				95% Confidence Interval of the Difference				
Group/ category	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1-Pre-category 5 - 1-Post-category 5	-7.94	20.08	4.38	-17.08	1.20	-1.81	20.00	0.09
2-Pre-category 5 - 2-Post-category 5	-15.70	23.09	5.60	-27.57	-3.83	-2.80	16.00	0.01
3-Pre-category 5 - 3-Post-category 5	-15.80	25.92	5.80	-27.93	-3.66	-2.73	19.00	0.01
4-Pre-category 5 - 4-Post-category 5	-7.72	28.34	6.68	-21.82	6.37	-1.16	17.00	0.26

Table 47

STAAR Total Statistics by Group

Test Statistics		1 Pre Total	1 Post Total	2 Pre Total	2 Post Total	3 Pre Total	3 Post Total	4 Pre Total	4 Post Total
N	Valid	21.00	21.00	17.00	17.00	20.00	20.00	18.00	18.00
	Missing	55.00	55.00	59.00	59.00	56.00	56.00	58.00	58.00
Mean		31.29	40.04	32.83	39.49	22.05	39.93	23.33	41.87
Median		29.44	38.78	33.33	41.17	20.27	37.44	26.10	39.56
Mode		46.67	23[a]	33.33	23[a]	3[a]	17[a]	0[a]	22[a]
Std. Deviation		12.49	13.10	12.06	11.31	14.40	14.81	13.80	11.18
Variance		156.02	171.48	145.44	127.99	207.50	219.20	190.57	124.94
Sum		657.09	840.83	558.19	671.33	440.95	798.67	419.85	753.61

a. Multiple modes exist. The smallest value is shown

Table 48

STAAR Total Pearson Correlations

Test totals	N	Correlation	Sig.
1_Pre-totals & 1_Post-totals	21.00	0.45	0.04
2_Pre-totals & 2_Post-totals	17.00	0.26	0.31
3_Pre-totals & 3_Post-totals	20.00	0.44	0.05
4_Pre-totals & 4_Post-totals	18.00	0.42	0.09

Table 49

STAAR Total Pearson Correlations

	Paired Differences							
				95% Confidence Interval of the Difference				
Test totals	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1_Pre-totals 1_Post-totals	-8.75	13.46	2.94	-14.88	-2.62	-2.98	20.00	0.01
2_Pre-totals 2_Post-totals	-6.66	14.22	3.45	-13.97	0.66	-1.93	16.00	0.07
3_Pre-totals 3_Post-totals	-17.89	15.44	3.45	-25.11	-10.66	-5.18	19.00	0.00
4_Pre-totals 4_Post-totals	-18.54	13.67	3.22	-25.34	-11.74	-5.76	17.00	0.00

Appendix G

MSLQ Tables Related to the Research Questions

Table 50

MSLQ Test of Homogeneity of Variance

Source	Based on	Levene Statistic	df1	df2	Sig.
MSLQ Pretest Totals	Based on Mean	2.23	3.00	72.00	0.09
	Based on Median	1.37	3.00	72.00	0.26
	Based on Median and with adjusted df	1.37	3.00	61.84	0.26
	Based on trimmed mean	2.09	3.00	72.00	0.11
MSLQ Posttest Totals	Based on Mean	0.19	3.00	72.00	0.90
	Based on Median	0.14	3.00	72.00	0.94
	Based on Median and with adjusted df	0.14	3.00	66.86	0.94
	Based on trimmed mean	0.15	3.00	72.00	0.93
STAAR Pretest Totals	Based on Mean	0.77	3.00	72.00	0.52
	Based on Median	0.66	3.00	72.00	0.58
	Based on Median and with adjusted df	0.66	3.00	68.17	0.58
	Based on trimmed mean	0.75	3.00	72.00	0.53
STAAR Posttest Totals	Based on Mean	0.39	3.00	72.00	0.76
	Based on Median	0.31	3.00	72.00	0.82
	Based on Median and with adjusted df	0.31	3.00	62.57	0.82
	Based on trimmed mean	0.32	3.00	72.00	0.81

Table 51

MSLQ within Subjects Factor

MSLQ	Dependent Variable
1	MSLQ pre-totals
2	MSLQ post-totals

Table 52. MSLQ Descriptive Statistics

MSLQ Descriptive Statistics

Test totals	Group type	Mean	Std. Deviation	N
MSLQ Pretest Totals	control	24.83	4.99	21.00
	Nspires	23.63	4.72	17.00
	Nspires, navigators	26.23	4.41	20.00
	Nspires, navigators, clickers	26.76	2.80	18.00
	Total	25.39	4.42	76.00
MSLQ Postttest Totals	control	25.65	4.33	21.00
	Nspires	26.47	4.00	17.00
	Nspires, navigators	26.45	4.92	20.00
	Nspires, navigators, clickers	27.67	5.12	18.00
	Total	26.52	4.58	76.00

Table 53

MSLQ between Subjects Factors

Group	Value Label	N
1.00	control	21
2.00	Nspires	17
3.00	Nspires, navigators	20
4.00	Nspires, navigators, clickers	18

Table 54

MSLQ Mauchly's Test of Sphericity

Within subject effect	Mauchly's W	Approx. Chi-square	df	Sig.	Epsilon[b] Greenhouse Geisser	Huynh Feldt	Lower bound
MSLQ	1.00	0.00	0	–	1.00	1.00	1.00

Tests the null hypothesis that the error covariance matrix of the ortho-normalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Group Type Within Subjects Design: MSLQ

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 55

MSLQ Box's Test of Equality of Covariance Matrices

Effect	Value
Box's M	10.73
F	1.13
df1	9.00
df2	52941.41
Sig.	0.34

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Group Type Within Subjects Design: MSLQ

Table 56

MSLQ within Subjects Effects

Source	Effect	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[a]
MSLQ	Sphericity Assumed	53.94	1	53.94	5.14	0.03	0.07	0.61
	Greenhouse-Geisser	53.94	1	53.94	5.14	0.03	0.07	0.61
	Huynh-Feldt	53.94	1	53.94	5.14	0.03	0.07	0.61
	Lower-bound	53.94	1	53.94	5.14	0.03	0.07	0.61
MSLQ * Group Type	Sphericity Assumed	34.75	3	11.58	1.10	0.35	0.04	0.29
	Greenhouse-Geisser	34.75	3	11.58	1.10	0.35	0.04	0.29
	Huynh-Feldt	34.75	3	11.58	1.10	0.35	0.04	0.29
	Lower-bound	34.75	3	11.58	1.10	0.35	0.04	0.29
Error MSLQ	Sphericity Assumed	755.57	72	10.49				
	Greenhouse-Geisser	755.57	72	10.49				
	Huynh-Feldt	755.57	72	10.49				
	Lower-bound	755.57	72	10.49				

a. Computed using alpha = .05

Table 57

MSLQ Multivariate Tests

Source	Effect	Value	F	Hypothesis df	Error df	Sig	Partial Eta squared	Noncent. parameter
MSLQ	Pillai's Trace	.07	5.14[b]	1.00	72	.03	.07	5.14
	Wilks' Lambda	.93	5.14[b]	1.00	72	.03	.07	5.14
	Hotelling's Trace	.07	5.14[b]	1.00	72	.03	.07	5.14
	Roy's Largest Root	.07	5.14[b]	1.00	72	.03	.07	5.14
MSLQ * Group Type	Pillai's Trace	.04	1.10[b]	3.00	72	.35	.04	3.31
	Wilks' Lambda	.96	1.10[b]	3.00	72	.35	.04	3.31
	Hotelling's Trace	.05	1.10[b]	3.00	72	.35	.04	3.31
	Roy's Largest Root	.05	1.10[b]	3.00	72	.35	.04	3.31

a. Design: Intercept + Group Type Within Subjects Design: MSLQ

b. Exact statistic

c. Computed using alpha = .05

Table 58

MSLQ within Subjects Contrasts

Source	MSLQ	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
MSLQ	Level 1 vs level 2	107.88	1	107.88	5.14	0.03	0.07
MSLQ * Group type	Level 1 vs level 3	69.51	3	33.17	1.1	0.35	0.04
Error (MSLQ)	Level 1 vs level 4	1511.14	72	20.99			

Table 59

MSLQ Tests of Between Subjects Effects

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Noncent. garameter
Intercept	101697.104	1	101697.10	3388.87	0.00	0.98	3388.87
ID group	87.402	3	29.13	0.97	0.41	0.04	2.91
Error	2160.656	72	30.01				

a. Computed using alpha = .05

Table 60

MSLQ Contrast Results

Group name	Simple contrast[a]		Averaged variable measure_1
Level 2 vs. level 1	Contrast estimate		-.52
	Hypothesized value		.00
	Difference (estimate - hypothesized)		-.52
	Std. error		1.26
	Sig.		.68
	95% confidence interval for difference	Lower	-3.04
		Upper	2.00
Level 3 vs. level 1	Contrast estimate		.41
	Hypothesized value		.00
	Difference (estimate - hypothesized)		.41
	Std. error		1.21
	Sig.		.73
	95% confidence interval for difference	Lower	-2.00
		Upper	2.83
Level 4 vs. level 1	Contrast estimate		1.60
	Hypothesized value		.00
	Difference (estimate - hypothesized)		1.60
	Std. error		1.24
	Sig.		.20
	95% confidence interval for difference	Lower	-.88
		Upper	4.08

Table 61

MSLQ Fisher's Least Significant Difference

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Control	Nspires	.52	1.26	.68	-2.00	3.04
	Nspire, navigators	-.41	1.21	.73	-2.83	2.00
	Nspire, navigator, clickers	-1.60	1.24	.20	-4.08	.88
Nspires	Control	-.52	1.26	.68	-3.04	2.00
	nspire, navigators	-.93	1.28	.47	-3.48	1.61
	Nspire, navigator, clickers	-2.12	1.31	.11	-4.73	.49
Nspire, navigators	Control	.41	1.21	.73	-2.00	2.83
	Nspires	.93	1.28	.47	-1.61	3.48
	spire, navigator, clickers	-1.19	1.26	.35	-3.70	1.32
Nspire, navigator, clickers	control	1.60	1.24	.20	-.88	4.08
	Nspires	2.12	1.31	.11	-.49	4.73
	nspire, navigators	1.19	1.26	.35	-1.32	3.70

Based on observed means.
The error term is Mean Square (Error) = 15.005.

Appendix H

STAAR Tables Related to the Research Questions

Table 62

STAAR within Subjects Factor

STAAR	Dependent variable
1	Pre total
2	Post total

Table 63

STAAR between Subjects Factor

Group number	Value label	N
1	Control	21
2	Nspires	17
3	Nspires, navigators	20
4	Nspires, navigators, clickers	18

Table 64

STAAR Descriptive Statistics

Test	Group type	Mean	Std. deviation	N
Pre total	1 - control	31.29	12.49	21
	2 - Nspires	32.83	12.06	17
	3 - Nspires, navigators	22.05	14.40	20
	4 - Nspires, navigators, clickers	23.33	13.80	18
	Average/total	27.32	13.82	76
Post total	1 - control	40.04	13.10	21
	2 - Nspires	39.49	11.31	17
	3 - Nspires, navigators	39.93	14.81	20
	4 - Nspires, navigators, clickers	41.87	11.18	18
	Average/total	40.32	12.56	76

Table 65

STAAR Box's Test of Equality of Covariance

Test	Value
Box's M	2.855
F	.301
df1	9
df2	52941.405
Sig.	.975

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Group Type Within Subjects Design: STAAR

Table 66

STAAR Mauchly's Test of Sphericity

Within subjects effect	Mauchly's W	Approx. chi-square	df	Sig.	Epsilon[b] greenhouse geisser	Huynh-Feldt	Lower-bound
STAAR	1.00	0.00	0.00		1.00	1.00	1.00

Tests the null hypothesis that the error covariance matrix of the ortho normalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Group Type Within Subjects Design: STAAR

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 67

STAAR Multivariate Tests

Test/group	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta squared	Noncent. parameter
STAAR	Pillai's Trace	.47	62.64[b]	1.00	72	.00	.47	62.64
	Wilks' Lambda	.53	62.64[b]	1.00	72	.00	.47	62.64
	Hotelling's Trace	.87	62.64[b]	1.00	72	.00	.47	62.64
	Roy's Largest Root	.87	62.64[b]	1.00	72	.00	.47	62.64
STAAR * Group	Pillai's Trace	.13	3.45[b]	3.00	72	.02	.13	10.35
type	Wilks' Lambda	.87	3.45[b]	3.00	72	.02	.13	10.35
	Hotelling's Trace	.14	3.45[b]	3.00	72	.02	.13	10.35
	Roy's Largest Root	.14	3.45[b]	3.00	72	.02	.13	10.35

a. Design: Intercept + Group Type Within Subjects Design: STAAR

b. Exact statistic

c. Computed using alpha = .05

Table 68

STAAR within Subjects Effects

Source	Test	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Noncent. parameter
STAAR	Sphericity Assumed	6336	1	6336.52	62	.00	.47	62.64
	Greenhouse-Geisser	6336	1	6336.52	62	.00	.47	62.64
	Huynh-Feldt	6336	1	6336.52	62	.00	.47	62.64
	Lower	6336	1	6336.52	62	.00	.47	62.64
STAAR * Group type	Sphericity Assumed	1047	3	349.01	3.45	.02	.13	10.35
	Greenhouse-Geisser	1047	3	349.01	3.45	.02	.13	10.35
	Huynh-Feldt	1047	3	349.01	3.45	.02	.13	10.35
	Lower	1047	3	349.01	3.45	.02	.13	10.35
Error	Sphericity Assumed	7283	72	101.16				
	Greenhouse-Geisser	7283	72	101.16				
	Huynh-Feldt	7283	72	101.16				
	Lower	7283	72	101.16				

a. Computed using alpha = .05

Table 69

STAAR within Subjects Contrasts

Source	Levels	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
STAAR	Level 2 vs. level 1	12673.03	1.00	12673.03	62.64	0.00	0.47
STAAR * Group type	Level 2 vs. level 1	2094.08	3.00	698.03	3.45	0.02	0.13
Error (STAAR)	Level 2 vs. level 1	14566.93	72.00	202.32			

Table 70

STAAR Tests of Between Subjects Effects

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Noncent. parameter
Intercept	172992.64	1	172992.64	727.87	.00	0.91	727.87
Group type	703.65	3	234.55	0.99	.40	0.04	2.96
Error	17112.25	72	237.67				

a. Computed using alpha = .05

Table 71

STAAR Contrast Results

Levels of Contrast	Simple contrast[a]		Averaged variable measure_1
Level 2 vs. level 1	Contrast estimate		.50
	Hypothesized value		.00
	Difference (estimate - hypothesized)		.50
	Std. error		3.56
	Sig.		.89
	95% confidence interval for difference	Lower	-6.59
		Upper	7.59
Level 3 vs. level 1	Contrast estimate		-4.67
	Hypothesized value		.00
	Difference (estimate - hypothesized)		-4.67
	Std. error		3.41
	Sig.		.17
	95% confidence interval for difference	Lower	-11.46
		Upper	2.12
Level 4 vs. level 1	Contrast estimate		-3.07
	Hypothesized value		.00
	Difference (estimate - hypothesized)		-3.07
	Std. error		3.50
	Sig.		.38
	95% confidence interval for difference	Lower	-10.05
		Upper	3.91

a. Reference category = 1

Table 72

STAAR Fisher's Least Significant Difference

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
control	Nspires	-.50	3.557	.889	-7.59	6.59
	Nspires, navigators	4.67	3.406	.174	-2.12	11.46
	Nspires, navigators, clickers	3.07	3.502	.384	-3.91	10.05
Nspires	control	.50	3.557	.889	-6.59	7.59
	Nspires, navigators	5.17	3.596	.155	-2.00	12.34
	Nspires, navigators, clickers	3.57	3.687	.337	-3.78	10.92
Nspires, navigators	control	-4.67	3.406	.174	-11.46	2.12
	Nspires	-5.17	3.596	.155	-12.34	2.00
	Nspires, navigators, clickers	-1.61	3.542	.652	-8.67	5.45
Nspires, navigators, clickers	control	-3.07	3.502	.384	-10.05	3.91
	Nspires	-3.57	3.687	.337	-10.92	3.78
	Nspires, navigators	1.61	3.542	.652	-5.45	8.67

Based on observed means.
The error term is Mean Square (Error) = 118.835.

Curriculum Vitae

Phyllis Camara

Education

Ph.D. Candidate Walden University, Educational Technology, 12/2013
MS – Management Science and Administration, University of Texas at Dallas, 8/1992
BS – Business Administration, UTD, 8/1994

Summary of Skills, Expertise, and Knowledge

-Experience with Microsoft Office
-Experience with computer applications and software

Professional Experience

1993 – 2013, Math Teacher, DISD, TX
1998 – Present, Adjunct Faculty, Richland College (DCCCD), TX
2013 – Present, Visiting Scholar Faculty, Richland College, TX

Association Memberships

Active Member of Delta Pi Chapter of Delta Kappa Gamma Society International for Key Women Educators.
Active Member of Kappa Delta Pi International Honor Society for Education