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The Effects of the Use of Technology In Mathematics Instruction on Student Achievement

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THE EFFECTS OF THE USE OF TECHNOLOGY IN MATHEMATICS

INSTRUCTION ON STUDENT ACHIEVEMENT

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by

Ron York Myers, Sr.

2009

To: Interim Dean Marie McDemmond
College of Education

This dissertation, written by Ron York Myers, Sr., and entitled The Effects of the Use of Technology in Mathematics Instruction on Student Acheivement, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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The dissertation of Ron York Myers, Sr. is approved.

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DEDICATION

I dedicate this to my grandparents Carl Elijah Hanna and Yvonne Louise Hanna (both deceased). Your lessons in life will always be remembered. My mother Beverly Elaine Myers raised all four of us by herself, and she never stopped praying for me. Momma, we have personally witnessed God's miracles; here is another one. To all of the ancestors, I am tall because I am standing on your shoulders.

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My hope and prayer is that this study will be used to increase the mathematics achievement of the thousands of kids that are disadvantaged when it comes to passing high stakes mathematics tests. High stakes mathematics tests are a regular part of the curriculum of most states in the United States of America. As times change so must the methods that are used to teach mathematics. Some teachers teach the same way that they were taught when they were in school. Children of today are more technologically savvy than children have ever been in the history of the world. Children need to be taught using the technology they use every day. Hopefully this study will contribute to closing achievement gaps, decreasing dropout rates, and increasing rates of graduation.

ABSTRACT OF THE DISSERTATION

THE EFFECTS OF THE USE OF TECHNOLOGY IN MATHEMATICS

INSTRUCTION ON STUDENT ACHEIVEMENT

by

Ron York Myers, Sr.

Florida International University, 2009

Miami, Florida

Professor Mohammed K. Farouk, Major Professor

The purpose of this study was to examine the effects of the use of technology on students' mathematics achievement, particularly the Florida Comprehensive Assessment Test (FCAT) mathematics results.

Eleven schools within the Miami-Dade County Public School System participated in a pilot program on the use of Geometers Sketchpad (GSP). Three of these schools were randomly selected for this study. Each school sent a teacher to a summer in-service training program on how to use GSP to teach geometry. In each school, the GSP class and a traditional geometry class taught by the same teacher were the study participants. Students' mathematics FCAT results were examined to determine if the GSP produced any effects. Students' scores were compared based on assignment to the control or experimental group as well as gender and SES. SES measurements were based on whether students qualified for free lunch.

The findings of the study revealed a significant difference in the FCAT mathematics scores of students who were taught geometry using GSP compared to those who used the traditional method. No significant differences existed between the FCAT

mathematics scores of the students based on SES. Similarly, no significant differences existed between the FCAT scores based on gender.

In conclusion, the use of technology (particularly GSP) is likely to boost students' FCAT mathematics test scores. The findings also show that the use of GSP may be able to close known gender and SES related achievement gaps. The results of this study promote policy changes in the way geometry is taught to 10^{th} grade students in Florida's public schools.

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CHAPTER I

INTRODUCTION

In January 2002, President George W. Bush signed into law the No Child Left Behind Act of 2001 also known as public law 107-110 (USDOE, 2009). The NCLB Act proposed an ambitious agenda to bring all children to grade level in both reading and mathematics by 2014 (Patrick, 2004). The NCLB legislation highlighted the importance of using the positional advantage that technology brings into a learning situation. The Act promoted using technology in all areas of k-12 education, including special education, reading, science, mathematics, and all other subjects.

The dynamic nature of technology forced educators to re-evaluate the mathematics that students need to determine the best methods for attaining higher levels of mathematics achievement. Many students are struggling to learn mathematics today. Some students might state that they hate math and feel that they will never use it in the future. Campoy (1992) has remarked that technology provides a better way of teaching mathematics. Technology is the great equalizer; technology brings everyone to the same level. It does not matter whether the student is a high achiever or a low achiever, teaching and learning through the use of technology takes the low and high level students to heights unknown (Campoy, 1992).

Background to the Study

The 2005 National Assessment of Educational Progress (NAEP) stated that Black 12th grade students scored 30 points lower than their White counterparts on every section of the mathematics portion of the nationwide test. In the 1980s and 1990s the achievement gap between minority and non-minority students had closed considerably.

Since the year 2000, however, the achievement gap has begun to widen to the levels of the 1970s (Waks, 2005). Too many students are not grasping or learning the mathematics being taught in the classrooms of schools. The results of the state mandated tests reflect the achievement gap is widening. The Florida Department of Education (FDOE), creators of the Florida Comprehensive Assessment Test (FCAT), released their results according to levels. Level Five was the highest possible score, a Level Three was considered the lowest passing score, and a Level One was the lowest score possible. In the state of Florida in 2004, 26% of the Black 10th grade students scored a Level One on the state mandated FCAT while only 5% of the non-minority students scored Level One (FDOE, 2006). That means that one out of every four Black 10th graders scored at the lowest level on the mathematics portion of the FCAT on the first attempt. That number amounts to almost 100,000 Black students that are walking the streets of Florida without having the minimum mathematics achievement score needed for many jobs or a high school diploma (FDOE, 2006). We need to examine the methods of teaching to ensure that all students have an opportunity to receive a high school diploma.

Lappan (1999) stated that in the Third International Mathematics and Science Study (TIMSS), students in the United States (U.S.) scored at or near the bottom in every geometry task. Usiskin (1987) stated that of all the students enrolled in U.S. high schools, only 63% can correctly identify different types of triangles and only 30% can write proofs. Clements (2003) stated that appropriately designed geometric software is designed to have a high level of interaction. He believed that by using geometric software students are unable to “hide” what they do not know.

Clements (2003) said that teachers must be ready for a big change when they teach with geometric software. He further stated that even teachers experienced with geometric software are sometimes not comfortable with using this software in the beginning. These teachers stated that they were not comfortable giving up control of the classroom and control of the students.

The National Council of Teachers of Mathematics (NCTM, 2000) listed six principles to assist and guide teachers in improving the content and delivery of mathematics instruction (NCTM, 2000). The six principles were equity, curriculum, teaching, learning, assessment, and technology. This study focused on one of these six principles, technology. The use of technology in mathematics education allows students the opportunity to focus less on the computational aspects and to focus more on the applications of mathematics (NCTM, 2000). In this study, Geometer's Sketchpad (GSP) was the technology used.

Rojano (1996) has indicated that with the appropriate use of technology, students can learn more mathematics and on a deeper level. Technology gives students the prospect of owning the mathematics that is being taught by providing more time for modeling and conceptualizing the mathematical ideas (NCTM, 2000). Through the use of technology, students are able to generate multiple representations of solutions. When using dynamic geometry software, students can immediately see the effects of changing the shape of an object. Students can observe the perimeter changing, the area increasing or decreasing, and the volume of a three dimensional object becoming greater or smaller. All of these changes occur in real time, thereby providing instant feedback, while at the same time allowing students the freedom to solve their problems without the restrictions of pencil and paper (NCTM, 2000). In geometry a progression also occurs. Van Hiele (1986) stated that a student must progress through five levels in order to fully understand geometry. These are the following:

1. Ability to recognize shapes;
2. Ability to state the properties of the different shapes;
3. Ability to abstractly group families of shapes and begin to create links between and among properties;
4. Ability to see the big picture in geometry and to understand fully why proofs are needed;
5. Ability to establish theorems in different axiomatic systems and is able to analyze and compare these systems.

Burger and Shaugnesy (1986) provided a more insightful description of the Van Hiele model for geometry. Their first level of the Van Hiele model was known as Holistic because students use imprecise properties to compare shapes (e.g., a cookie is like a circle). Students sometimes use irrelevant attributes to identify shapes and their comparisons are idiosyncratic. They called second level Analytic because students begin to focus on the necessary properties of shapes. Subjective grouping of shapes are used instead of conventional ones. At the Analytic level, students do not have a good appreciation of proofs; they might think that geometric theorems can be established as true by evidence from a number of examples. Third, at the Abstract level, students can create and express definitions for shapes. They have a good understanding of the conventional groupings of shapes, and students can form short chains of reasoning even linking if-then statements. Fourth, at the Deductive level, students can see the overall structure of geometry. They recognize that formal proofs are needed to establish the truth of a conjecture, and students understand the roles of definitions, theorems, axioms and other tools of discourse in geometry. Last, in the fifth level, students can engage in the study of different axiomatic systems and reason rigorously within them.

In an empirical clinical case study of a single student, Choi-Koh (1999) was able to move the student through the Van Hiele levels through the use of dynamic geometry software. The use of the dynamic geometry software in Choi-Koh's study allowed the student to see shapes change and to examine the different areas, volumes, and perimeters in real time. He discovered that the student was able to learn more and to understand on a deeper level when the computational aspects were removed and the student was able to focus on the applications of solving geometry problems. Choi-Koh investigated moving one student through the Van Hiele levels of geometric thought by using dynamic geometry software. On the other hand, the present study was interested in investigating the mathematics achievement of an entire group of students using dynamic geometry software. Groves (1993) was of the opinion that technology influences the mathematics being taught as it enhanced students' learning because students use technology in school and at home. He stated that technology was essential in the teaching and learning of mathematics. Rojano (1996) stated that, once the computational aspects of mathematics are removed, the real learning can begin. He maintained that students learn mathematics more deeply when using technology. Technology allows the student the luxury of focusing on the concepts that are being taught and removes the burden of the computation (Rojano, 1996). When Choi-Koh was able to remove the computational aspects by using

GSP, his student was able to focus on the geometry and was able to quickly increase his Van Hiele levels.

As was stated earlier, the NCTM (2000) has six principles for school mathematics. This dissertation touched on equity, curriculum, teaching, and learning. It focused on the technology principle because, "The existence, versatility, and power of technology make it possible and necessary to reexamine what mathematics students should learn as well as how they can learn it" (NCTM, 2000 p. 24).

Furinas and Marinas (2006) stated that computers are an important part of everyone's life, and as children become adults, they need to learn to use computers to prepare them for the future. They also stated that teachers of mathematics help to increase students' understanding of the concrete to abstract by using hands on manipulatives and the current geometry sketching software. Furinas and Marinas went on to say that, based on Piaget's research, students need to feel the mathematics through hands-on manipulations, see the mathematics through dynamic geometry software, and make decisions and conjectures seeing geometric shapes change right before their eyes.

Moses and Cobb (2001) saw technology as the great equalizer. Their discussions on the teaching of algebra support the belief that technology assists in organizing thoughts. They saw technology as an inevitable consequence of changing times. Technology was reminiscent of a train coming down the tracks with a full head of steam, and there is nothing that can be done to stop it. One can either get on board or be run over by technology.

Problem Statement

Dewey (1933) stated that a problem arises out of some difficulty that is felt, something that makes a person dissatisfied, and something that puzzles a person and makes that person unsure about something. Merriam (1998) has indicated that a problem is something that challenges the mind and makes a person bewildered. This study examined a problem that is bewildering many school districts, how to increase the achievement of 10th grade geometry students (FDOE, 2006). Many past studies have used GSP to move students through the Van Hiele levels (Choi-Koh, 1999; Jiang & McClintock, 2000; McClintock, Jaing, & July, 2002), but few studies have studied how GSP affects students' mathematical achievement. The research problem explored in this study is a problem that is directly related to the gaps of information observed in the field of mathematics education: what is the effect of the use of GSP on students' Florida Comprehensive Assessment Test (FCAT) results? The FCAT is a mandatory exit examination given to all 10th grade students in the state of Florida. All students are required to pass the FCAT in order to receive a high school diploma. If students do not pass the FCAT by the time they have completed the 12th grade, these students will receive a certificate of attendance. A certificate of attendance states that, even though a student attended school for 12 years, he or she did not meet the requirements to receive a high school diploma.

Technology is a comprehensive tool that can be used to springboard students from one level of conceptual understanding to the next. Choi-Koh (1999) showed how technology, particularly Geometer's Sketchpad (GSP), moved a student's learning of geometry from one level of understanding to the next in rapid succession. This study examined the relationship between the use of GSP and non-GSP on the geometry FCAT (Florida Comprehensive Assessment Test) scores of 10th grade students in the Miami-Dade County Public School (MDCPS) System. Comparisons were based on socio-economic status and gender. The issues of socio-economic status and gender will be discussed further as this study moves forward.

Students that learn higher level mathematics are more likely to go to college and are more likely to qualify for advanced technical training in the military and the civilian workforce (Moses & Cobb, 2001). Moses and Cobb believe that students who learn higher level mathematics are better problem solvers in high school and beyond. Students that learn higher level mathematics can evaluate an abstract situation more concisely than a student who is not a high level mathematical thinker (NCTM, 2000). If students increase their ability to solve abstract mathematical problems, then they can improve their lot in life and more easily move on to the next level, which is college, the military or the workforce (Moses & Cobb, 2001).

If both boys and girls learn mathematics in the same classrooms, then why do boys traditionally exhibit higher levels of achievement? The 2005 NAEP study discussed that boys scored higher than girls on the mathematics portion of the examination. This study examined if there was an interaction between gender, GSP use and scores on high stakes mathematics examinations. This study was also undertaken to help determine if the achievement of students of lower socio-economic status can show mathematical improvement through the use of differing teaching methods, in particular the use of Geometer's Sketchpad (GSP).

Assumptions of the Study

1. Learning through the use of technology is unavoidable in today's society.
2. Using technology can motivate students to learn geometry.

Research Questions

The primary research question that was investigated in this study is: What is the effect of the use of GSP on the achievement of 10th grade geometry students as measured by their FCAT mathematics scores? The secondary research questions are:

1. Is there an interaction between the use of GSP and the gender of the students on FCAT mathematics scores?
2. Is there an interaction between the use of GSP and SES on FCAT mathematics scores?

Significance of the Study

This study involved 10th grade students in predominantly African-American and Hispanic schools in the Miami Dade County Public Schools (MDCPS). Although other grades also take the FCAT, this study focused on 10th grade students. Students in the 10th grade are required to pass the FCAT in order to receive a high school diploma; this study examined the effects of GSP on the achievement of 10th grade geometry students to determine if the use of GSP helped students to pass the FCAT. These high stakes tests are determining whether students receive a high school diploma or a certificate of attendance. In the state of Florida, all 10th grade students are required to pass the FCAT in order to receive a diploma. Without a diploma these students are guaranteeing themselves lives filled with temporary employment, minimum wage jobs, and a greater probability of incarceration (Moses & Cobb, 2001).

Anick, Carpenter, and Smith (1981) stated that Black students complete about a year less of high school mathematics than their White counterparts. Compared to White students, Black and Hispanic students are not learning mathematics on a deeper, more abstract level (Moses & Cobb, 2001). The 2005 NAEP study showed that minority students were lagging behind their non-minority counterparts. Moses and Cobb (2001) stated that a permanent underclass is being created because minority students are not learning higher mathematics at the same rate as non-minority students. Minority students are moving away from higher level mathematics, not towards it. Moses and Cobb (2001) believe that higher mathematics is the key to upward mobility.

Lower socio-economic students have routinely scored lower on standardized exams than their more affluent counterparts. Technology may be the great equalizer, as Moses and Cobb (2001) proclaim. Lubienski (2007) stated that lower SES children are not as motivated to learn as higher SES students. She states that lower SES children need to be more active in the learning process. She believes that lower SES children can learn, but they need to be taught with a more hands-on approach. Technology may be able to level the playing field in this area of disparity.

Hyde, Fennema, and Lamon (1990) found that boys achieve mathematics at higher levels than girls when both are in high school. Girls have traditionally scored lower than boys on mathematics achievement tests (Rebhorn & Miles, 1999). Hyde et al. (1990) thought that girls were more interested in other areas and did not think that mathematics is important. They state that boys are more interested in the hard sciences and think more strategically than girls at the high school level. The present study determined if the use of GSP would affect the mathematics achievement gap between boys and girls. This study helped to determine if the use of technology assisted girls in closing the gender gap.

Findings from this study can assist Miami-Dade County Public Schools (MDCPS), similar school districts and the state of Florida and in deciding if using GSP can increase the high school graduation rate of students by increasing the number of students that pass the mathematics portion of the FCAT. This study can assist in setting education reform policies and developing strategies that can be used to improve the delivery of the geometry curriculum. Questions about whether technology could be used to increase FCAT geometry scores were examined closely in this study.

Delimitations of the Study

1. Only teachers that had completed the MDCPS GSP training program were invited to participate in this research study;
2. Only students in the invited teachers' classes participated in this research study;
3. Only students in the experimental group had access to the computers that had GSP loaded on them;
4. The control group did not have access to the laboratory where the GSP software was loaded on the computers.

Definitions of Terms

Assessment and Accounting Briefing Book (AABB). FCAT Assessment and Accounting Briefing Book is written by the state of Florida to offer specific information concerning the details of the Florida Comprehensive Assessment Test.

FCAT mathematics achievement. The scores on the actual FCAT, scores range from level one to five; a level three or above is considered passing.

FCAT Strands. The FCAT Mathematics Achievement is actually a compilation of five individual scores: (a) Algebraic thinking (b) Number Sense (c) Geometry (d) Data Analysis (e) Measurement. These scores are calculated to form one overall FCAT score.

GSP. Geometers Sketchpad, a dynamic geometry software program that allows students to create and manipulate shapes and to study geometry in greater detail.

High SES. Students that do not qualify for free or reduced lunch.

Independent variables. A manipulated variable in an experiment or study whose presence or degree determines the change in the dependent variable.

Low SES. Students that qualify for free or reduced lunch.

Minority. Students that are predominantly from African-American and Hispanic backgrounds.

Summary

Many students are failing mathematics. Students of color are failing the FCAT at a rate that is five times that of Whites; Hispanic students are failing at a rate three times that of Whites (FCAT, 2009). Minority students are disproportionately failing the FCAT and not receiving diplomas. At a time when students should be preparing themselves for a life full of hope and potential, some students are preparing themselves for a life of hopelessness and despair. This study was undertaken to find out if teaching mathematics through the use of technology might be one way to reverse the trend of failing scores on the FCAT.

One aspect of this study examined the gender gap in mathematics education. Boys have typically outperformed girls on mathematics achievement tests. This study was undertaken to determine if teaching mathematics through the use of technology might be a solution to closing the gender gap.

This study also sought to determine how the use of technology might affect the FCAT results of students that ate free lunch or reduced lunch compared to the students that did not qualify for free or reduced lunch. Overall, this study investigated whether the use of GSP assisted students in passing the FCAT mathematics examination. This study attempted to explore one way to assist with the goal of increasing mathematics achievement.

This study is organized into five chapters. Chapter 1 discusses the problem that was studied. Chapter 2 discusses some of the literature that surrounds this study. Chapter 3 discusses the methodology that was used to extract the results of this study. Chapter 4 discusses the results of this study; and finally, chapter 5 summarizes, concludes, and poses areas for future research.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter provides an overview of the research and literature pertaining to this study. The theoretical framework, the questions that were examined in the study, the literature on the effectiveness of GSP, the literature on the mathematical achievement of males and females and the literature surrounding the mathematics achievement of students from low socio-economic backgrounds are discussed.

Research Questions

The primary research question that was investigated in this study is: What is the effect of the use of GSP on the achievement of 10th grade geometry students as measured by their FCAT mathematics scores? The secondary research questions are:

1. Is there an interaction between the use of GSP and the gender of the students on FCAT mathematics scores?
2. Is there an interaction between the use of GSP and SES on FCAT mathematics scores?

Theoretical Perspective

The theoretical perspective of this study was the constructivist theory of learning. The constructivist theory was chosen because it builds on prior knowledge: students use what they already know to make connections to new material. When students make these connections, they are learning new material and relating it to what they already know (Dewey, 1916). McClintock, Jiang, and July (2002) discussed how GSP is based on the constructivist theory of learning, because knowledge is actively constructed by the students while they are making constructions and analyzing figures instead of knowledge being passively received and accepted. Many educators today believe that the constructivist theory is a relatively new theory in education although the tenets of constructivism can be traced back to Socrates. Socrates was well known for asking his students questions that would stretch their minds and force them to think on a higher level (Tredennick & Tarrant, 1993).

John Dewey was the creator of the project method, a method that encourages students to work together in groups and to figure out the solutions to different problems that may arise as they continue to complete the assigned project (Dewey, 1916). John Dewey and Jean Piaget are the leading Progressive Education theorists of the last century. Dewey (1916) stated that the project method is a method of discovery and proof in so much as “all thinking results in knowledge, ultimately the value of knowledge is subordinate to its use in thinking” (p. 151). The way that we interpret things is the eye that we see them through. Dewey thought that the student is dynamically involved in the learning that is going on around him/her, and the instructor should only be considered a director of the learning and not an actor (Joyce, Weil, & Calhoun, 2002).

Piaget (1971) stated that the mind’s primary function is to create and to see things in a way that can be organized into a schema that helps the mind to see them as being real. Piaget was a strong proponent of cognitive development. He believed that as children grows older, they look at the world through different experiences, and that children have completely different perspectives than adults (Robinson, 2004). Piaget (1980) stated that, when knowledge is constructed within oneself, it is examined against what is happening in the real world in much the same way that a scientific idea is tested.

Some modern day constructivist theorists are Vygotsky, Brunner, and Von Glasersfeld. Von Glasersfeld (1987) has stated that the constructivist view involves two principles:

1. Knowledge is always being created, built up by learner. It is not inertly established;

2. Coming to know is a course of action based on the learner's constant adaptations to the experiences of the world.

Von Glasersfeld (1996) is a major proponent of abstract ideas that reflect one's situations to build conceptual structures through self regulation. He has stated that real learning happens when one takes ownership of the problem.

Huitt (2003) stated that, while Vygotsky was a social constructivist theorist, activity theory and situated learning, however, were the main tenets of his research. Vygotsky developed a "zone of proximal development," which is basically the difference between what a child knows and what that child is taught by others (Vygotsky, 1978). He believed that children learn through social interaction and by learning to solve problems with others. He called this process "scaffolding."

Brunner (1973) stated that learning is a process that occurs through social interactions, and students generate new knowledge by building onto what they already know:

> The student selects information, constructs hypotheses, and makes decisions, with the aim of integrating new experiences into his existing mental constructs. It is cognitive structures that provide meaning and organization to experiences and allow learners to transcend the boundaries of the information given. For him, learner independence, fostered through

> encouraging students to discover new principles of their own accord lies at the heart of effective education. Moreover, curriculum should be developed in a spiral manner so that students can build upon what they have already learned. (Cited in Thanasoulas, 2008)

This review of literature includes the constructivist theory of learning because the students in this study actively built on what they already knew in order to gain an understanding of geometry. The instructor was actively engaged in leading the students as they encountered their zone of proximal development (ZPD). The students were also actively engaging in the process of scaffolding as they sought assistance from more advanced students in their geometry classes.

Student Perspective

Groman (1996) discovered that through the use of GSP, students can construct medians of triangles and create conjectures that could eventually lead to the students writing proofs and thinking on higher levels. Groman contended that GSP teaches students through the vehicle of the constructivist theory. Mann (1994) stated that in the constructivist theory, students are in control of their learning, they do not just memorize facts. He contended that students learn through personal experience and must be actively engaged in the learning process. From a constructivist perspective, the roles are often reversed because teachers and students learn from one another. When learning through the constructivist theory, children learn from whole to part. The ideas and interests of children should drive the learning process. According to Piaget (1971), the constructivist theory student activities must be learner-centered and not curriculum-centered. He believed that the needs of the student are the main concern when selecting activities and not what the teacher needs to teach. He believed that children need to acquire "schemas" in order to obtain knowledge. He defined schemas as a set of ideas, perceptions, and actions. A schema can be considered forming relationships; it can be concrete or discrete. For example, a child recognizes a dog, and when that child sees different types of dogs, the child can then see that the dogs are different in some way. Because the child recognizes that the dogs are different, the child can learn that one is a bulldog and the other is a chow. As the child develops more, new schemas are developed. Piaget (1971) stated that this is how learning occurs. In the present study, students were required to form new schemas through the use of GSP as the students use the dynamic software to evaluate geometric properties.

Teacher Perspective

According to Gray (1997), constructivist classrooms must have certain characteristics such as the following,

1. Constructivist classrooms are student-centered;
2. Constructivist teachers employ negotiation because the teacher is not just disseminating knowledge but facilitating learning;
3. Teachers in constructivist classrooms are researchers;
4. Power and control in constructivist classrooms are shared.

She remarked that it is important to focus on the students because they are the "meaning makers" of the knowledge that is being disseminated. She stated that negotiation is important because it allies the students and teacher into a common purpose. She stated that it is important to individualize each class specifically for those students that are in class at that specific time. Constructivist teachers allow the students to provide input as to where to go next in the learning process. She indicated that constructivist teachers must research their students on a daily basis by monitoring their progress, assessing their needs, and digging in deeper to accommodate the way each student learns. She felt that giving the students the power is of the utmost importance in order for a classroom to be truly constructivist; children have to know that they are in control of what they are thinking (Gray, 1997).

Caine and Caine (1990) created 12 principles of constructivist teaching that will be quoted directly due to the complexity and the wideness in range of each individual principle.

1. "The brain is a parallel processor." It simultaneously processes many different types of information, including thoughts, emotions, and cultural knowledge. Effective teaching employs a variety of learning strategies.
2. "Learning engages the entire physiology." Teachers can't address just the intellect.
3. "The search for meaning is innate." Effective teaching recognizes that meaning is personal and unique, and that students' understandings are based on their own unique experiences.
4. "The search for meaning occurs through 'patterning'." Effective teaching connects isolated ideas and information with global concepts and themes.
5. "Emotions are critical to patterning." Learning is influenced by emotions, feelings, and attitudes.
6. "The brain processes parts and wholes simultaneously." People have difficulty learning when either parts or wholes are overlooked.

7. "Learning involves both focused attention and peripheral perception." Learning is influenced by the environment, culture, and climate.
8. "Learning always involves conscious and unconscious processes." Students need time to process 'how' as well as 'what' they've learned.
9. "We have at least two different types of memory: a spatial memory system and a set of systems for rote learning." Teaching that heavily emphasizes rote learning does not promote spatial, experienced learning and can inhibit understanding.
10. "We understand and remember best when facts and skills are embedded in natural, spatial memory." Experiential learning is most effective.
11. "Learning is enhanced by challenge and inhibited by threat." The classroom climate should be challenging but not threatening to students.
12. "Each brain is unique." Teaching must be multifaceted to allow students to express preferences. (Caine and Caine, 1990, pp. 66-69)

Teaching through the use of the constructivist theory requires hard work on the part of the classroom teacher, and it also requires the students to work in an active manner. Constructivist teaching and learning removes the direct burden of the teacher being the sole disseminator of information and changes the role of the teacher into being the facilitator and not the primary source of all learning. One must, however, question the growth that each student is claiming at the end of the process (Brunner, 1973). The present study was based on the constructivist learning theory along with the use of GSP, so that the effects of the use of GSP on 10th grade geometry student’s achievement based on gender and SES could be investigated.

Using Technology

Moses and Cobb (2001) believe that minority students can learn mathematics on a higher level through the use of technology. They began the “Algebra Project” because they believed that learning mathematics is a civil rights issue. They see technology as the great equalizer, and technology helps us to organize our thoughts. They believe that algebra is the language of computers, and in order for students to be computer literate, they must have an understanding of algebra. According to Moses and Cobb (2001), algebra is the gateway to higher mathematics. In order for one to move on to advanced courses, one must have a firm understanding of algebraic concepts. They believe that algebra should be taught in the seventh grade. They have stated that by taking algebra in the seventh grade, students are on a track that has them in calculus by the time they graduate from high school. They also have noted that students can get a better understanding of the subject through the use of technology. They believe so fervently in the Algebra Project that they compare learning mathematics to having the right to vote and enjoying one’s civil rights. They purported that if children do not learn mathematics, then they are preparing themselves to join the ranks of the permanent underclass, and that algebra is the road to upward mobility. Children that do not or cannot learn mathematics are ensuring themselves of a “sharecropper’s education,” an education of lowest expectations. There are many ways to improve the curriculum and instruction in mathematics and science. One of the most effective ways to assist students in learning better is through the use of technology (Moses and Cobb, 2001).

Technology comes in many forms. Technology can be something as simple as the use of calculators in mathematics and science, using an overhead projector, a computer in the classroom for student use, or the many, new software programs that are beginning to flood the educational market place. The key to teaching students higher levels of mathematics through technology is having teachers that can teach the technology (Alagic, 2003). Alagic (2003) stated that many teachers teach mathematics the same way that mathematics was taught to them. That is why so many more experienced teachers teach using the lecture method because they were taught this way, and they are more comfortable teaching this way. Moses and Cobb (2001) stated that the Apple computer company invented the personal computer in 1976 and it took between 10 and 15 years for the price of computers to become economical enough for a family to afford. Many of today's students are very computer savvy, whereas many experienced teachers are learning from their students.

Alagic (2003) believes that teachers can learn in many ways, but it is hard for them to pass on their knowledge to the students directly because they have different experiences and understanding from children. Some students are very advanced with technology tools, and they often challenge their teachers to reach their levels. One of the principles that the National Council of Teachers of Mathematics (NCTM) posits is important for helping students to gain a greater conceptual understanding of advanced mathematics is the use of technology (NCTM, 2000). Technology is seen as the way to help gain a more in-depth understanding of the intricacies of higher mathematics. Alagic (2003) says that technology enables users to learn because some technologies are interactive. He believes that interactive technologies like GSP allows the user the opportunity to observe changes instantly, thereby understanding better what happens when some dimension of a figure is changed. Students can immediately observe that the area of a figure changes as the length and width is changed. Technology removes the computational constraints and therefore extends learning beyond what can be done without technology.

The NCTM (2000) standards state that technology should not be used to work out problems without gaining an understanding of what is happening behind the scenes. This situation is analogous to using a calculator to compute the square root of a number but not understanding what the solution means or how the calculator computed the answer. The NCTM Principles and Standards of 2000 states students can easily explore the effects of changes in the parameters of functions through the use of technology, thereby getting a better understanding of functions overall. The goal of using technology for understanding forces us to think about what is happening behind the scenes in the actual mathematics operations, leading to more ways of solving and understanding problems (NCTM, 2000).

Van Hiele Levels

The Van Hiele theory was developed by a husband and wife team of mathematicians. The Van Hieles discovered that in order for a student to understand geometric concepts on higher levels, students must progress through the levels of their theory (Van Hiele, 1986). Student progression through the theory levels is very closely related to progression through the levels of Bloom's Taxonomy. Both theories are constructivist theories. Both theories begin at an elementary level of thought and advance until a student has reached the level of rigor. Each stage of Van Hiele's five levels of Geometric Thought advances a student's level of understanding until the student reaches the final stage which is the level of rigor. Van Hiele's five levels of

Geometric Thought are actually six stages according to Usiskin (1982). According to Usiskin (1982) the levels are the following:

Level Zero: Pre-recognition. At this level, students are unable to fully identify many common shapes.

Level One: Visual/recognition. Students can recognize a shape by its appearance.

Level Two: Analytical/ descriptive. This level is called the "aspect of geometry." Students at this level can identify shapes based on properties rather than appearance.

Level Three: Abstract/ relational. This level is called the "essence of geometry." At this level students can use accurate definitions rather than a list of properties when identifying shapes, if-then reasoning, logical arguments about properties, and informal proofs.

Level Four: Formal deduction. This level is called the "discernment of geometry..." At this level students can make conjectures and prove them with formal proofs.

Level Five: Rigor. At this level learners understand how geometry proofs and concepts fit together to create the structure we call geometry, to appreciate the distinctions and relationships between different axiomatic systems, to compare and contrast different axiomatic systems.

Unlike Piaget's theory, the Van Hiele theory is based on instructional techniques and not age (Usiskin, 1982).

Many of the FCAT questions involve analysis, synthesis, and evaluation. The FCAT examination does not solely use Bloom's Taxonomy, because Bloom's Taxonomy requires an inference about the skill, knowledge, and background of the students responding to the item (Florida Department of Education, 2008).

Beginning in 2004, the Florida Department of Education (FDOE) implemented a new cognitive classification system based upon Norman L. Webb's Depth of Knowledge (DOK) levels. The rationale for classifying items by their level of complexity is to focus on the expectations of the item, not the ability of the student. The demands on thinking that an item makes -- what the item requires the student to recall, understand, analyze, and do -- are made with the assumption that the student is familiar with the basic concepts of the task (Webb, 2004).

Webb's Depth of Knowledge (DOK)

Webb's Depth of Knowledge (DOK) measures the cognitive complexity and rigor of an item. DOK does not view tests items as taxonomy; instead an item is observed as a hierarchy. DOK is concerned about the progression of the rigor that is learned and taught. DOK is determined by the item and not by the students' level of knowledge. DOK progresses as steps, each more advanced than the one before. Students cannot advance to the next level until they have attained the previous level (Webb, 2004).

Webb's DOK is separated into four levels, beginning with level one and ending with level four. Each level is separated into three major categories of complexity. The categories are low complexity, moderate complexity, and high complexity. Low complexity mathematics items can be solved in one step. Moderate complexity items can be solved using multiple steps, and high complexity items require in-depth thinking and analysis (FDOE, 2008).

The DOK levels are:

Level One: Recall (recall a fact or procedure, low complexity);

Level Two: Skill/Concept (conceptual knowledge, low-early moderate complexity);

Level Three: Strategic Thinking (reasoning, developing a plan, moderate complexity);

Level Four: Extended Thinking (analysis and investigation, high complexity) (Williams, 2009).

The DOK levels are very closely aligned with the Van Hiele Levels.

Van Hiele Levels		Webb's DOK Levels
Levels Zero and One	corresponds to	Level One
Level Two	corresponds to	Level Two
Level Three and Four	corresponds to	Level Three
Level Five	corresponds to	Level Four

Using GSP

One of the greatest software advancements being used in today's classrooms is the dynamic geometry software called Geometer's Sketchpad (GSP). GSP is distributed through the Key Curriculum Press. Choi-Koh (1999) conducted a clinical study on a single student to see if he could move the student along the Van Hiele levels of geometric thinking through the use of GSP. He discovered that the student learned how to work the software in a short period of time and quickly worked his way up the ladder of the Van Hiele levels.

In Jiang and McClintock's (2000) multiple approaches to problem solving, they state that mathematics must be made more rigorous because students that comprehend difficult coursework, particularly higher level mathematics, are more successful in their everyday lives, and they make higher salaries. Jiang (2002) proposed that through the use of GSP students can move along the Van Hiele levels and reach the level of rigor.

GSP is a dynamic program that allows students the opportunity to see geometric concepts in motion. Students get to see what happens to the area of a circle as the radius is increased and decreased by the movement of a computer mouse. Students may examine the areas of figures as the lengths of the sides of the figures are increased or decreased. Students can observe how the angles of a triangle fluctuate as they move the sides of the triangle to change the shape of the triangle from obtuse to acute. It does not matter how the shape of the triangle changes, the sum of the three angles remains constant (Jiang and McClintock, 2000).

McClintock, Jiang, and July (2002) conducted a 4-year study on a group of 24 low-socioeconomic, seventh grade minority students to determine if the use of GSP can assist in moving students' Van Hiele levels to a higher level. The researchers were interested in determining what role the GSP environment could play in the development of students' 3-D visualization. Through the use of GSP directed activities, observations of the students, interviewing the students at regular intervals and assessments, the students' Van Hiele levels increased on average two levels. At the outset of the McClintock et al. study, the students were tested and the results determined that the students displayed varying Van Hiele levels. When the students were re-tested at the end of the study, the result showed an average two Van Hiele level increase. The authors attributed the students' growth to the use of GSP through guided discovery activities (2002). That study is important to the field of mathematics education because it shows that, through the use of technology, particularly GSP, minority students increased their understanding of geometric concepts by increasing their Van Hiele levels of understanding. The present study, however, differs from the McClintock et al. (2002) study because the researcher was interested in investigating the effect of the use of GSP on 10^{th} grade geometry students' achievement, including interaction with gender and SES, and not just the students' Van Hiele levels. Further, the McClintock et al., study did not have a control group whereas the present study does.

In an empirical clinical case study on a single student, Choi-Koh (1999) was able to move the student through the stages of the Van Hiele levels through the use of dynamic geometry software. Choi-Koh discovered that the student is able to learn more and to understand on a deeper level when the computational aspects are removed, and the student is able to focus on the applications of solving geometry problems. Although Choi-Koh was concerned about one student, the present study was interested in exploring the effect of the use of GSP on an entire group of students. The McClintock et al. (2002) and the Choi-Koh (1999) study are both based on using GSP to increase students Van Hiele levels. The present study, however, was concerned about using GSP to determine the effects that it has on students' mathematics FCAT scores (achievement).

Dix (1999) conducted a study to determine if there is a difference in the achievement of students that used GSP versus students that used a traditional pencil and paper method. Her study is based on a pre-test post-test design using The Standard Progressive Matrices Test (Raven, 1960) commonly referred to as Raven’s test. This examination tests students’ pattern recognition to determine their non-verbal ability to reason.

Her subjects were two eighth grade classes; one class was the experimental group (used GSP), and the other was the control group (used pencil and paper). Dix reported that the treatment was not effective in increasing the mathematical ability of the experimental group based on Raven’s test, the use of an end of the unit mathematics tests, and the students’ responses on a survey questionnaire.

Although Dix’s (1999) statistical analysis did not reveal a significant difference between the Raven’s test results and an end of the unit test, the GSP group scored marginally lower than the traditional group. She posited that this might be because prior to her study, none of the students had any experience with using GSP. The present study also examined mathematics achievement using GSP as a treatment. However, the present study is based on the use of FCAT mathematics results, and the students were in the 10^{th} grade. Raven’s test measures pattern recognition. The end of the unit test that Dix’s students took was titled “Tessellations and Angle Sum in a Polygon”. The students in the present study were tested on (a) Algebraic thinking; (b) Number Sense; (c) Geometry; (d) Data Analysis; and (e) Measurement, the five strands of the FCAT.

Groman (1996) discovered that through the use of GSP, students can construct angle bisectors of triangles and make conjectures that could eventually lead to the students writing proofs. The students in that study determined that with a click of the mouse, they could grab the vertex of triangles, change their shapes, and manipulate their angles. However, the bisectors retained their places as bisectors through this manipulation. Sketchpad allows the students to make instant assessments in real time of the data as they were changing. Groman contended that GSP can be used to teach students through the vehicle of the constructivist theory, depending on how the students are using the dynamic software. She discovered that her students were able to build onto their previous knowledge through the use of GSP. She was impressed that the students thought positively of their sketchpad experience, and the students became enthusiastic about a mundane subject like geometry (1996). Through the use of sketchpad, the researcher changed hats from the instructor to a learner. Groman's study was important because it shows how students can use GSP to make discoveries in real time, and how GSP can motivate students to think on higher planes. Groman's study found that the use of GSP helped to increase her students' motivation. Although GSP was shown to be a great motivator, GSP was not documented to have increased achievement levels on standardized tests.

Gray (2008) stated that while the use of GSP in a mathematics classroom has "great value as an educational tool" it cannot solely be used to teach mathematics. He contended that the "monotony" of using GSP all day, every day would bore students, and they would quickly tire of using this dynamic software.

Gray (2008) stated that through the appropriate use of GSP, mathematics classrooms can move from yesterday into tomorrow or, to put it in another way, from the industrial age into the information age. He stated that in order for teachers to use GSP in their classrooms, they must alter their curriculum in a big way. He believes that teachers need to devote several class periods to training students on how to use GSP before any significant results can be revealed. He believes that GSP should supplement the textbook or hands-on activities, not replace them (2008).

Hannafin, Burress, and Little (2001) conducted a study to examine the effects of GSP on student and teacher motivation. The findings of that study focused on issues of control and learning. The study was conducted on 12 seventh grade students in two classes in a rural community. The teacher agreed to give up control of the classroom to the researchers to see if through the use of GSP students would excel in geometry. The teacher was an experienced teacher who has always been in charge of her classroom and of the learning that occurs, but in that study the teacher did not feel comfortable giving up control, because she had no input into the design of the study and felt that her real allegiance was to the administration at her school and to the parents of the students in the study (Hannafin et al., 2001). Although that study involved the constructivist theory of learning, the researchers were more interested in instructivist theory of learning, a combination of constructivism and objectivism (Hannafin et al., 2001). Nevertheless, that study found that GSP increased the likelihood of students being motivated to work. Their study, however, made no distinctions between the achievement of boys and girls. The Hannafin et al. study was focused on using GSP to increase student and teacher motivation, the present study was interested in the effect that the use of GSP has on student achievement.

One of the goals of the Hannafin et al. (2001) study was to move the students beyond the Zone of Proximal Development (ZDP) which Vygotsky (1978) described as the place where students moved beyond what they knew by themselves to where they began learning with the assistance of the teacher. In this case, the GSP software program provided assistance. Hannafin et al. (2001) pointed out that GSP was not a teacher or a constructivist model in itself. They used structured activities and questions that guided the students to think about the changes that were occurring before their eyes and to hypothesize what would happen if certain changes were made. The students quickly realized that through the use of GSP, the figures could be grabbed, clicked, and dragged by the mouse to be manipulated and conjectured about. Hannifin et al. concluded that the use of GSP with the assistance of the teacher moved students beyond the ZPD. However, that phenomenological study failed to state if the use of GSP increased the achievement levels of the students.

Hannafin and Scott (1998) discovered that GSP using students with high aptitudes scored better than their GSP using low-aptitude counterparts on subordinate categorized questions that were based on recalled facts and on higher ordered categorized questions. However, it is worth noting that the lower aptitude students improved dramatically through their use of GSP. The Hannafin and Scott (1998) study did not examine the distinctions between students of low socio-economic status (SES) and students with high socio-economic status SES, nor did that study examine student achievement as the present study did.

Hannafin (1999) stated that many veteran teachers have become set in their ways, and the need to change is not a priority to them. Hannafin’s study revealed that the teacher in that study resisted giving up full control of the learning environment and the students. Properly using GSP requires that teachers adopt a constructivist theory of learning, giving up control and becoming facilitators of knowledge instead of directors (1999). In a later study, Hannafin (2001) stated that since the teacher in that study had no part in designing the study, she was not sure what direction the study might take, and of even more importance, if the study would improve her students' test results on the required statewide assessment that is prevalent in most states. That study demonstrated how some teachers resist the use of GSP, especially if they are not properly trained as to the benefits of using GSP. The teachers in the present study learned about these benefits as they attended a 3-day session designed to train them on the use of GSP.

The teacher made it clear to the researchers in the Hannafin (2001) study that her responsibility was to the students' parents, her school administration, and the other stakeholders in her students' education. Even though the teacher agreed to participate in the study, she found it difficult to stay involved until the end of the study. The teacher believed that it was her sole responsibility to distribute knowledge. The teachers was not sure of what the students were or were not learning and felt as if she had to direct the learning where she wanted it to go. On the other hand, the students commented on how they liked learning geometry through the use of the GSP exercises. The students felt that they were in control when using GSP and the teacher felt as if she was giving up her control of the learning environment. This teacher was very uncomfortable with the lack of control.

The surveys that the students took revealed that they enjoyed having the opportunity to work independently, and that they were motivated by working on computers (Hannafin 2001). This finding is supported by Kenzie and Sullivan (1989) who stated that the motivation level of students that participated in computer-based instruction increased. Since the students are more motivated to learn, they are more likely to use the computers without the teacher prompting them to do so. The Hannafin (2001) study revealed that students liked doing geometry on computers, and that GSP motivated the students to work hard. However, this is where the Hannafin study and the present study differ. The present study sought to determine if GSP helps to increase students' levels of understanding on the statewide achievement test called the FCAT.

De Villiers (2002) stated that GSP helps students to immediately discover whether a conjecture is right or wrong. He said that by playing with a figure and examining angle measures on the screen, a student can increase his or her confidence in the assessment of a conjecture by using the drag feature of GSP and by seeing if the shape and angles of a figure changes or remains constant, thus gaining immediate feedback. He stated that this is more convincing than performing an actual proof, because this is an instant process and alleviates the need for a lot of mathematical language. De Villiers did not comment on how this may deter students from writing proofs. He expressed the opinion that writing proofs is outdated. He said that if students can produce a counter example, they are using deductive methodology in its truest form.

Jiang (2002) conducted a study on the use of GSP on two college pre-service teachers. These college students were completing the final requirement before becoming full-time, certified teachers in the state of Florida. Jiang's purpose for conducting that study was to determine if GSP helped to improve the students' abilities to write proofs and increase the students' reasoning in mathematics.

Jiang also observed the pre-service teachers' learning processes as they worked with the GSP dynamic geometry software. Jiang's study involved a constructivist approach in instruction and learning, and the study lasted 10 weeks. One of Jiang's objectives was to raise the students' Van Hiele levels through the use of GSP. The students were interviewed two times a week for 75 minutes each time. Sometimes the students were interviewed together, sometimes apart. Jiang used a pre-test, post-test design using the Mayberry instrument to determine the students' Van Hiele levels, Jiang also used information from his interviews with the students to assess their understanding of the material and to examine their thought processes (Jiang, 2002).

Jiang (2002) determined that GSP works differently with each individual student. What the students discover through the use of GSP is dependent on the students' abilities before GSP is used. He also discovered that GSP is an exceptional instrument that enhances a students' ability to write proofs and increases their reasoning in mathematics.

The first pre-service student in Jiang's study increased his Van Hiele level from a level two to a level three, while the second student in Jiang's study moved from a Van Hiele level three to a level four. Jiang's study, however, failed to address the issue of using GSP to increase achievement on the statewide assessment tests that teachers are required to take before they are fully certified in the state of Florida.

Clements (2003) stated that appropriately designed software goes hand in hand with geometric ideas of very high levels. He noted that computer environments provide students with a boost of independence and promote their individual understanding of geometric concepts, because students can manipulate objects in ways that they could not do with pencil and paper.

Mathematics and Gender

Tiedemann (2000) observed that in the first through third grades, girls tend to outperform boys in mathematics achievement. Hyde, Fennema, and Lamon (1990) confirm that by high school the exact opposite is occurring. The boys are outperforming the girls. Hyde et al. (1990) suggested that this dramatic turn of events occurs because in high school less computation is needed, and girls are better at computation.

However, Tiedemann (2000) stated that when teachers are consulted, they believe that the difference in achievement between boys and girls is prevalent because boys are more logical, and therefore, they have a built-in advantage over the girls because mathematics is logical. He stated that teachers believe that sometimes girls can compete with boys in high school mathematics, but this is only because some girls know how to try harder when the need arises.

Tiedemann (2000) conducted a 2-year longitudinal study of boys and girls in grades four, five, and six to determine if boys were mathematically superior to girls in the early grades. His study involved three teachers and 75 students. He concluded that there were no significant differences in mathematics achievement based on the gender of the students. However, Tiedemann's subjects were in the early grades, and the participants in the present study were in 10^{th} grade geometry. Students in the present study were be evaluated to see there is an interaction between the use of GSP and gender.

Jussim and Eccles (1992) conducted a 2-year longitudinal study of students in the sixth grade. The purpose of the study was to examine teachers' beliefs about the gender of the students and to determine their effects on student performance in mathematics. They determined that (a) the teachers as well as the students held different beliefs for the boys and girls in mathematics, (b) the teachers felt that the average achieving boys were more logical than the average achieving girls and (c) the teachers rated mathematics more difficult for the average achieving girls than for the boys on the same level. Finally, concerning the girls, (d) the teachers stated that their failures have less to do with a lack of effort and more to do with low ability (Jussim & Eccles, 1992).

The boys in the Jussim and Eccles (1992) study outperformed the girls in mathematics; the present study was interested in determining if there is an interaction in the achievement scores of boys and girls and the use of GSP. The present researcher believed that through the use of GSP, teacher bias was minimal at best, and further, that GSP provides a platform that increases the motivation levels of all students. Jussim (1989) concluded that when it comes to girls that range from below average to average in mathematics achievement, they must try much harder than the below average to average boys to achieve the same results. The findings leaned in the direction that the boys were more talented and exerted more effort towards learning mathematics than the girls. Eccles et al. (1990) observed similar results in the way that parents look at their sons and daughters differently.

MacGregor and Thomas (2002) conducted a study to determine the effectiveness of a student directed approach of using GSP to complete a project based task compared to a teacher directed approach. There were 82 tenth grade students from four geometry classes that met daily for 50 minute sessions. The students were from an all girls private parochial academy that is nationally recognized for its academic prowess. They assigned the same project to both groups to determine the learner outcomes that occurred as the students completed the project. The primary goal of the project was to design and find the cost of making a garden that would be built on the campus.

The results of the MacGregor and Thomas (2002) study revealed that in the short term the teacher directed group had higher learning outcomes. The teacher directed group was characterized by a greater sense of direction and was less frustrated than the group of girls working with the GSP software alone. However the self- directed group expressed a sense of pleasure and an increase in self-confidence with a sense of pride in their accomplishments.

One should be wary of applying these results across student populations because most parents that can afford to send their daughters to an all-girl, private parochial academy are rarely low SES challenged. Also, one must consider the levels of motivation those students at a top tier private academy have over students at a school where many of the students are struggling both financially and academically (2002).

Tiedemann and Steinmetz (1997) stated that girls were less logical thinkers than boys, and that the unexpected success that some girls experienced was due more to effort and less to ability. Through the use of dynamic geometry software, the present study discovered if gender biases could be observed through an interaction in the achievement scores of boys and girls.

Rebhorn and Miles (1999) conducted a study to determine if high stakes testing is a barrier to middle-school gifted girls. They hypothesized that if girls scored lower than boys on standardized mathematics tests, then it would adversely affect their opportunity to be accepted into specialized mathematics programs that could eventually lead to networking opportunities, college admissions, and the ability to learn how to interact in higher level academic settings. They revealed that there is a 30 point difference (favoring the boys) in all of the mathematics scores of girls and boys on the Scholastic Achievement Test (SAT). They stated that boys are more likely to be accepted into gifted mathematics programs if the SAT math test is the lone determinant. They discovered that accelerated university-based programs that target gifted students have many more boys than girls participating.

Benbow and Stanley (1983) determined that of all the students that took the mathematics portion of the SAT and scored at or above 500 (out of a possible 800 total), about 67% were boys. They revealed a few advantages of participation in university programs for gifted middle-school boys: The boys ended up with a enhanced self esteem, superiority due to working with the cream of the crop, improved preparation for the future, a desire to learn more, a feeling that school is a good thing, a desire to be better qualified to attend higher echelon colleges, and improved researching abilities. According to Olszewski-Kubilius and Grant (1996), something special happens to the girls that attend these specialized programs as well. These girls are more likely to take Advanced Placement (AP) classes once they go to high school. The AP courses assist the girls in being able to make technical career choices, being exposed to college and career counseling, and being provided opportunities to be mentored by girls that are upperclassmen. They posited that when girls are given an opportunity to excel on higher levels they have more opportunities than girls that do not score high on mathematical tasks. The present study sought to determine if GSP has the potential to assist girls in increasing their mathematics achievement.

Rebhorn and Miles (1999) stated that boys have an unfair advantage over the girls on the SAT due to gender bias that is built in to the SAT examination. Although their study brought to light built-in gender biases in standardized tests, it did not include consideration of the students' SES in its discussion of results. Their study did not use dynamic geometry software to prepare their students for the SAT. The present study was based on the use of GSP to examine its effects on students' achievement as measured by their mathematics FCAT results. By using this dynamic geometry software both the boys and the girls had the same opportunities to learn and excel. The questions of differences in mathematics scores due to gender were closely examined.

Dix (1999) conducted a study on eighth grade girls and boys using GSP as a treatment for the experimental group and pencil and paper for the control group. She also administered a computer attitudinal survey. The results of her survey revealed a significant difference in the ways that girls and boys think about the use of computers. That study revealed that boys and girls thought positively about the use of computers. However, an analysis of the survey results revealed that the boys thought more positively about the use of computers. Dix's study also showed that through the use of technology, girls can improve their thinking on mathematical tasks, thereby giving the girls more inspiration to perform just as well as the boys or possibly even outperform the boys in mathematics.

Altermatt and Kim (2004) stated that boys outperform girls in mathematics because the boys were exposed to hormones in the womb that lead to more analytical thinking in the brain and to increased spatial abilities. They also stated that some girls suffer from "low confidence and high uncertainty," and that these qualities are exposed during mathematical thinking. They expounded on another theory that states girls are more likely than boys to want to please others, whereas boys are more competitive, and this may account for the discrepancy between the mathematics test scores of boys and girls. The present study was interested in comparing the mathematics FCAT scores of boys and girls to determine if the use of GSP affected the mathematics scores of the girls enough to close the gender gap.

Parents play a large role in the perceptions of their children's attitudes towards mathematics (Leedy, Lalonde, & Runk, 2003). Leedy et al. stated that boys exude higher confidence levels in their mathematics abilities because boys view mathematics as a male dominated arena. The researchers suggested that girls have less confidence in their mathematical ability, and believe that their mothers expect less from them mathematically than do their fathers. Further, they stated that teachers have different perceptions of boys and girls mathematically, and that the teachers in their study showed preferential treatment towards the boys and paid less attention to the girls' mathematical abilities. These results were based on a survey that was given to all of the participants, including the parents. The purpose of this survey was to examine how the parents and students viewed mathematics. The girls, as well as their mothers, thought that the survey was insulting and biased against women because the questions were geared to show male dominance.

Martinot and De'sert (2007) examined a group of fourth and seventh graders to explore whether they were aware of gender stereotypes. According to the results of the study, seventh grade boys believed that the girls were academically superior in mathematics. The girls, on the other hand, held deep-seated beliefs that their mathematical abilities were lower than that of the boys'. That study opens a window into the minds of girls and boys and provides additional support for claims that boys think differently than girls.

Bracey (1994) discovered that boys look at mathematical problems differently than girls do. Boys use a "top-down" approach in which they quickly identify what category a problem belongs to and make adjustments accordingly, whereas girls use a "bottom-up" method in which they look for patterns as they pull together information from the problem. Bracey theorized that girls are more likely than boys to spend time examining "irrelevant" information as they attempt to solve a problem. Bracey stated that boys quickly discard irrelevant information and stick to the rules and algorithms for solving problems. Through the use of GSP students can instantly make and examine conjectures and determine quickly if certain properties are relevant or not. The use of GSP may be able to assist girls in solving the problem more effectively.

Sprigler and Alsup (2003) conducted a study on 120 boys and 119 girls in grades one through five in a rural South Dakota community. They observed that students in elementary school do not demonstrate a gender gap in mathematics. They also stated that gender differences in mathematics begin to occur in the middle grades, and that when time constraints are removed from tests there, girls perform just as well or better than boys.

All of the studies reviewed here reported the same conclusions, that in the lower grades girls outperform boys in mathematics. As students move into the middle grades, boys are expected to take the lead in mathematical abilities over the girls. Beginning in middle school the boys do take a lead in mathematics achievement. The present study was interested in discovering if the use of GSP can assist girls in closing the mathematics achievement gap that has been documented in the higher grades.

Socioeconomic Status

The No Child Left Behind (NCLB) Act of 2001 states that by 2010 all children should be working on grade level. NCLB was written to close the achievement gap between minority and non- minority students and between students of low and high SES. The NCLB act called for that all elementary and secondary students to be working at least on grade level within the 10 years (Bush, 2001). While the promises of the NCLB are lofty and admirable, the realities are completely different. Many school districts and students are getting left behind.

In 2004, the Miami Dade County public schools implemented a “School Improvement Zone,” known as the “Zone.” The Zone was a collection of schools and feeder patterns from largely poor neighborhoods that consistently lagged in achievement behind the schools in more wealthy neighborhoods. The purpose of the Zone was to assist the poorer schools by offering more resources and a longer school day to allow students there to catch up with students in the more affluent schools. The MDCPS school improvement zone was a 3-year project that ended at the end of the 2007-2008 school year. An evaluation of the program was conducted by the MDCPS with a final program evaluation report in May 2009. While the evaluation determined that the Zone was mildly effective in increasing student mathematical achievement on the FCAT, the improvement was not statistically significant (OPE, 2009). One of the schools in the present study was designated as a Zone school. The present study sought to determine if through the use of GSP, the students in the Zone schools might significantly increase their mathematics FCAT scores.

Lubienski (2007) stated that in order for everyone to learn mathematics, the obstacles that economically disadvantaged students face on a daily basis must be addressed. She stated that despite the huge changes that have occurred in the way that economically disadvantaged students have been taught since 1989, students with higher SES have continued to increase the achievement gap even to the point of the difference being more than several grade levels (Lubienski, 2002).

Lubienski (2007) gave several reasons why children of lower SES were not on the same academic level as children of higher SES. One reason is that the low SES students fought against attempting to learn mathematics through discussion and problem solving. She stated that many higher SES students bounce ideas off of one another and discuss different ways of solving problems. She stated that many low SES students did not understand the underlying mathematical concepts that were being discussed. Higher SES students made conscious attempts to learn mathematics without the constant help of the instructor.

The lower SES students often told the instructor “tell me the answer,” and “how do you do it?” without making any attempts to discover the answers for themselves. She found that the lower SES students quickly became confused and were not sure if they were properly solving the problem whereas the higher SES students usually observed that the same mathematical ideas were being repeated in different ways. She also noted that lower SES students often used a common sense approach to reasoning through mathematical situations and were often engaged in the semantics of a problem, thereby allowing the mathematical point of a problem to pass them by. The present study attempted to discover if through the use of GSP lower SES students can close the achievement gap with their higher SES counterparts. The present study was undertaken in the hope that through the use of GSP, lower SES students might build on what they already know, discover new concepts, and build new schemas.

According to Lubienski (2007), sustained mathematical achievement is the way to higher paying occupations, and students of lower SES should be aware that the more they learn, the better their chances are of getting higher paying jobs. She went on to say that lower SES students are more likely than higher SES students to memorize mathematical facts, and this practice is highly correlated with negative mathematical achievement. In the present study it was hoped that through the use of GSP, students would motivated to do mathematics. Further, it was hoped that the lower SES students would learn and discover mathematical concepts that might assist them in scoring higher on the mathematics portion of the FCAT.

The hidden curriculum states that parents of low SES students are intimidated by schools and often feel attacked or under fire by teachers at parent conferences. As a result these parents are less likely to attend these meetings to seek help for their children. On the other hand, parents of higher SES students are known to attend these meetings and demand that their child receive help (if needed); they are willing to seek higher authority to ensure that their child is not forgotten (Lubienski, 2007). Lubienski suggested that more resources were needed to ensure an equitable education for students with low SES, and that the best teachers and lower class sizes were needed in the lower level classes because that was where students needed the most help. Through the use of GSP, the present study sought to assist the lower SES parents by eliminating the need for those parents to seek mathematical help for their children by assisting the children to score higher on the mathematics section of the FCAT. Once students pass the mathematics portion of the FCAT, they are one step closer to graduation. Students that did not pass the mathematics portion of the FCAT are required to continue taking the FCAT until they pass the examination, or they are no longer eligible to attend public schools.

Ogwu (2004) had stated that parents that have high socio-economic status have greater access to outside resources for their children's educational attainment. He stated that high socio-economic parents have the ability to send their children to schools of high standards and are able to purchase computers, learning toys, and other amenities that parents of children of low socio-economic status cannot afford. The students of higher SES parents have everything that they need to be successful, whereas students of lower SES parents do not have everything that they need to be successful. Advantages such as private tutors, home computers, and special summer programs are luxuries that low SES parents sometimes cannot afford. The present study provided a computer laboratory that all students in the experimental group had access to during their geometry classes.

Cherian (1993) conducted a study to determine if the sex of students along with their SES status had an effect on mathematical achievement of fifth grade boys and girls. Cherian discovered through a two way ANOVA, that the sex of the students had an insignificant effect on the mathematics achievement of boys and girls ($F(2, 1011) = 150.3$, $p< .01$). When student SES was factored in, there was a significant effect on the interaction of sex and socioeconomic status ($F(2, 1011) = 5.31$, $p< .01$). The mean mathematical achievement of boys and girls was not the same at the high, medium and low SES levels. The low SES girls had a mean score of 88.1, and the low SES boys had a mean score of 80.7. The medium SES girls had a mean score of 114.9 and medium SES boys had a mean score of 126.5. The high SES girls had a mean score of 137.2 and the high SES boys had a mean score of 151.1. The researchers observed that the higher the SES, the better the boys and girls scored, thereby exhibiting an interaction between the sex of the student along with their SES (Cherian, 1993). The present study sought to determine if there was an interaction amongst the mathematics FCAT scores of low and high SES students and the boys and the girls through the use of GSP.

Summary

This chapter began with a discussion of the research questions and the theoretical perspective of this study. Student and teacher perspectives were discussed to show how the theoretical learning model of constructivism was used in this study. The literature on the use of technology was discussed in detail. The Van Hiele levels of geometric thought were discussed in detail because many of the studies that related the use of GSP were focused on increasing Van Hiele levels through the use of GSP. The present study added to the available literature by examining how the use of GSP affects FCAT mathematics scores.

The effect of the gender gap on students was discussed and suggestions on how to address this problem were highlighted. Suggestions about how to improve the mathematical achievement of low socio-economic students were discussed in detail. Students of low SES have consistently scored lower than their higher SES peers. Something has to be done to teach and to motivate these low SES students to reach for higher mathematical achievement. The present study investigated whether through the use of GSP lower SES students might learn and discover new mathematical concepts that could assist them in scoring higher on the mathematics portion of the FCAT. The literature indicates that through the use of technology, students have been assisted to excel and to be motivated to continue learning.

The next chapter will discusses the methods of this study, the research questions, the hypotheses, the research design, the participants, the control group, sampling procedures, the instruments, the variables, the data collection procedure, the statistical treatment, the limitations. The chapter concludes with a summary.

CHAPTER III

METHODS

This chapter explains the methods used in this study. The research questions, research design, sampling procedures, variables, the statistical treatment, and the limitations of the study will be discussed.

Research Questions

The primary research question that was investigated in this study is: What is the effect of the use of GSP on the achievement of 10th grade geometry students as measured by their FCAT mathematics scores? The secondary research questions are:

1. Is there an interaction between the use of GSP and the gender of the students on FCAT mathematics scores?
2. Is there an interaction between the use of GSP and SES on FCAT mathematics scores?

Hypotheses

1. Students taught mathematics using GSP will score higher on the FCAT mathematics test than students who do not use GSP;
2. There is an interaction between the use of GSP and the gender of the students in determining their FCAT mathematics scores;
3. There is an interaction between the use of GSP and the SES of students in determining their FCAT mathematics scores.

Participants

One geometry teacher from each of the 11 schools in the Miami-Dade County Public Schools district participated in a training program on the use of Geometer Sketch Pad (GSP) during the summer preceding this study. These 11 schools were chosen because the FCAT mathematics test scores of their students were lower than expected. The students in these schools came from different social economic backgrounds based on the numbers of the students that qualified for free or reduced lunch compared to the students that did not qualify. Four of the schools were located in affluent neighborhoods, three of the schools were located in middle class neighborhoods, and five of the schools were in neighborhoods with high poverty levels. Of the 11 schools, three were randomly selected for this study. The participating teachers in these three schools were contacted, and they agreed to participate in this research. Each of these teachers taught multiple sections of geometry, and one of these sections was randomly chosen to use the GSP while a second section was randomly chosen not to use the GSP and to serve as the control group. The students in the experimental and control classes were thereby taught by the teacher who taught same geometry objectives using the same textbook (*Discovering Geometry*, published by Key Curriculum Press). The two treatments differed only in that the experimental classes went to the computer laboratory once a week to solve geometry problems from the discovering geometry book using GSP. When the classes of the three teachers were combined, 46 participants made up the experimental group and 49 students made up the control group.

Procedures

This section describes the teacher training procedures used in the summer sessions. It also indicates how the participants were recruited and how data were obtained.

Teacher Training Program

During the summer intersession when teachers were off from work, the 11 selected schools sent one teacher from each school to receive training on how to use Geometers

Sketchpad (GSP). The workshop was titled: Infusing Geometer's Sketchpad in Mathematics for Beginning Users. The workshop lasted 3 days and was taught by the Curriculum and Instruction: Mathematics Education Department of the Miami-Dade County Public Schools. Day 1 focused on constructions, theorems, geometric properties, transformations and designs. Day 2 focused on quadrilaterals, triangles, angle bisectors, altitudes, medians and string art. Day 3 focused on points, planes, lines (parallel, perpendicular and intersecting), slopes, and linear equations.

Each day ended with a reflection of what was learned. The teachers were given tips and advice on the best practices for passing on what they had learned to the students in their classrooms. The teachers were given examples on the best ways to show students how to construct figures. The teachers were also given examples on how to use the reflection properties of GSP to make new figures, and on how to properly measure angles. The workshop was designed for teachers that had no experience with working with GSP. Although no formal surveys were given to the teachers, one or two of the teachers had been exposed to the GSP software program while in college, however some of these teachers admitted to the trainers, to being "a little rusty" on the use of GSP since their exposure had been several years ago.

Sample Recruitment

A letter seeking approval for the study was sent to the principals of the three randomly selected schools requesting authorization for the teachers in their schools to participate in the research. When authorization was obtained, a letter requesting permission for their child to participate was sent home to the parents of these students. While students remained in their assigned classes whether or not their parents granted permission, data were collected only for students whose parents granted permission.

Data Sources

At the end of the school year the participants' FCAT mathematics test results were collected. In order to statistically equate the experimental and control groups, FCAT mathematics scores from the previous year were collected for use as covariates.

The FCAT has proven to be a reliable and valid exit examination. According to the AABB (2007), the FCAT's mathematics portion internal consistency reliability score using Cronbach's alpha was .93 in 2001, .92 in 2002 and .92 in 2003. These scores indicate a high level of internal consistency reliability.

The Sunshine State Standards (SSS) are a set of objectives that are used in all Florida public schools and are used to guide the construction of the Florida Comprehensive Achievement Test editions. These standards provided satisfactory levels of content related evidence for the validity of the test. The evidence of reliability and validity supports the claim that FCAT is technically sound and meets or exceeds the standards for standardized achievement tests (AABB, 2007).

Data Analysis

This section of the dissertation describes the variables that were used in the data analysis. It also indicates the statistical procedures that were used to test the hypotheses.

Variables

The variables used in this study were the five dependent variables (the individual strand scores) and the independent variables were the use of GSP, the students' gender, and their SES as measured by their eligibility for free or reduced lunch. The five strand scores of the mathematics FCAT are algebraic thinking, number sense, geometry, data analysis, and measurement. In order to statistically equate the experimental and control groups on mathematics ability, the five strand scores obtained by the participants on the FCAT mathematics test in the previous year were obtained and used as covariates.

Statistical Treatment

The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 17.0. The data was subjected to a 2x2x2 MANCOVA with five dependent variables making up a canonical function that can be thought of as a measure of mathematics achievement. The 2x2x2 MANCOVA represents GSP use versus non-GSP use, boys versus girls and low versus high SES. The FCAT developmental scores were used since they consist of interval scale data.

Limitations

One limitation of this study was the generalizability of the results. The students chosen for this study were a small sample of a population that is very diverse in ethnicity and limited in location. This small population may be very different from populations in other parts of the United States of America as well as the entire world. Other limitations may be the techniques that the individual instructors bring into their diverse classrooms. No two teachers teach exactly alike. Although all three teachers were trained on how to use GSP in their classrooms the individual ability levels of the teachers may differ.

Summary

This chapter began with a discussion of the research questions examined in this study. Points of discussion were: the research design procedures of selecting the participants and control group, the sampling procedures, the variables and the data collection procedures. The statistical treatment and limitations of the study were discussed. The following chapter reports the results and the analysis of the data collected to determine if the use of technology helped improve FCAT results as well as examine the discrepancy between gender and students of low-SES compared to students of high-SES.

CHAPTER IV

RESULTS

This chapter presents the findings of the study. This chapter also presents the research questions that guided the study. The hypotheses and the demographic information about the participants will be discussed in this chapter. The results of the data analysis are presented.

Research Questions

The primary research question that was investigated in this study is: What is the effect of the use of GSP on the achievement of 10th grade geometry students as measured by their FCAT mathematics scores? The secondary research questions are:

1. Is there an interaction between the use of GSP and the gender of the students on FCAT mathematics scores?
2. Is there an interaction between the use of GSP and SES on FCAT mathematics scores?

Hypotheses

1. Students taught mathematics using GSP will score higher on the FCAT mathematics test than students who do not use GSP;
2. There is an interaction between the use of GSP and the sex of students in determining their FCAT mathematics scores.
3. There is an interaction between the use of GSP and the SES of students in determining their FCAT mathematics scores.

The following section presents demographic data about the participants.

Demographic Information

Eleven schools were chosen to participate in a pilot program with the Miami-Dade County Public Schools (MDCPS). The 11 schools were chosen because their FCAT scores were lower than what they were expected to be compared to the FCAT scores of the students from the previous school year. The students in these schools come from different socio-economic backgrounds. Three of the schools served very affluent areas, three of the schools were located in middle class neighborhoods, and five of the schools were in neighborhoods with high poverty levels. Three of the 11 schools were randomly selected from this stratified sample to participate in this study. In each school the teacher who had been trained in the use of the Geometer's sketchpad the previous summer taught one of his/her classes. The teacher that received the GSP training was chosen by the administration of the school. Students in these classes made up the treatment group in the study. Students in other classes who returned parental permission forms constituted the control group. The entire sample consisted of 96 students. School Number One had 30 students participate, School Number Two had 34 students participate, and School Number Three had 32 students participate. The students in these teachers' classes that did not use GSP made up the control group.

Miami-Dade County Public Schools (MDCPS) was the largest school district in Florida and the fourth largest in the nation. MDCPS had an enrollment of 414,128 (as of February 15, 2007). The MDCPS had the most Black and Hispanic students in the country with 60% if its students being of Hispanic origin, 28% African American, 8% White and 3% non-White or other minorities. The district had a total of 392 institutions, including (a) 195 elementary schools, (b) 54 middle schools, (c) 10 K-8 centers, (d) 31 high schools, (e) 50 charter schools, (f) 23 vocational adult schools, (g) 5 magnet high schools, (h) 18 alternative schools, and (I) 5 special education (specialized centers) (School Information, 2007). Table 1 presents the number of students in MDCPS according to their race and ethnicity as well as the percentages of each group.

Table 1
Miami-Dade County Public Schools (MDCPS) Demographics

Race/Ethnicity	Number of Students	Percentage
White (Non Hispanic)	33,131	8%
Black (Non Hispanic)	115,956	28%
Hispanic	248,476	60%
Asian/Indian/Mixed	16,565	3%
Total	414,128	100%

High school number 1 had grades 9-12 and was located in the City of Miami Gardens. The surrounding neighborhood was lower-middle to middle class, with an average property assessment value of $90,000 to $250,000. This translated into 41% of the students receiving free or reduced lunch. At the time of the study, 13.1% of the students were serviced by Exceptional Student Education (ESE) programs and received support services. Two and two tenths percent of the students were classified as Limited English Proficient (LEP) students', that is, students that spoke limited English (School Information, 2007). Most limited English students are student's have recently moved from other countries and now reside in the U.S.

School Number 1

Table 2 presents the number of students in school number 1 according to their race and ethnicity as well as the percentages of each group.

Table 2
Demographics of School Number 1

Race/Ethnicity	Number of Students	Percentage
White (Non Hispanic)	22	0.80%
Black (Non Hispanic)	2529	93.70%
Hispanic	129	4.78%
Asian/Indian/Mixed	19	.72%
Total	2699	100.00%

Table 3 reflects the percentages of the students in school number 1 that participated in this research study according to their race and ethnicity. There were 16 students in the experimental group and 14 in the control.

Table 3
School Number 1: Demographics of Students Involved in the Study

Race/Ethnicity	Percentage	Number of Students
White (Non Hispanic)	0%	0
Black (Non Hispanic)	93%	27
Hispanic	7%	3
Asian/Indian/Mixed	0%	0
Total	100%	30

The faculty and staff at school number 1 were very diverse. The faculty was 52% Black Non Hispanic, 8% Hispanic, 33% White Non Hispanic, 6% Indian, and 1% Asian. This multicultural faculty was also very well educated. As depicted by the school characteristics, 40% of the instructional staff had Master's degrees, 11% of the instructional staff had Specialist degrees, and 6% of the instructional staff had obtained Doctoral degrees. Within the Math Department, 40% of the teachers were men, 60% of the teachers were women, 16% were White Non Hispanic, 80% were Black Non Hispanic, 4% were Hispanic, and 30.7% of the department members had obtained graduate degrees (School Information, 2007).

School Number 2

School number 2 was located in Kendall, a suburb of Miami, Florida. The surrounding neighborhood was middle to lower upper class, with an average property assessment value of $250,000 to $475,000. This translated into 27.9% of the students receiving free or reduced lunch. The overall population of school number was 2, 3589 students in grades 9-12 and was comprised of a student body that was 24% White Non Hispanic, 20% Black Non Hispanic, 51% Hispanic and 5% Asian/Indian/Multiracial. Table 4 presents the number of students that were in school number 2 according to their race and ethnicity as well as the percentages of each group. At the time of this study 15.6% of the students were serviced by Exceptional Student Education (ESE) programs and received support services. 5.2% of the students were considered Limited English Proficiency Students (LEP) or students that spoke limited English (School Information, 2007). Most LEP students are student's that have recently moved to the U.S. from a country where a different language was spoken the majority of the time.

Table 4

Demographics of School Number 2

Race/Ethnicity	Number of Students	Percentage
White (Non Hispanic)	861	24%
Black (Non Hispanic)	718	20%
Hispanic	1830	51%
Asian/Indian/Mixed	180	5%
Total	3589	100%

Table 5

School Number 2: Demographics of Students Involved in the Study

Race/Ethnicity	Percentage	Number of Students
White (Non Hispanic)	13%	4
Black (Non Hispanic)	28%	10
Hispanic	54%	18
Asian/Indian/Mixed	5%	2
Total	100%	34

The faculty and staff at school number 2 was 56% White, 14% Black, 29% Hispanic and 1% Asian/Indian/Multiracial. Thirty four percent of the instructional staff had a Master's Degree, 10% had a Specialist degree and 1% had their Doctoral Degrees. Within the Math Department 59% of the teachers were men and 41% were women, 18% were Black Non Hispanic, 50% were White Non Hispanic and 32 % were Hispanic, and 70.9% of the mathematics faculty had obtained graduate degrees (School Information, 2007). Table 5 reflects the percentages and the number of the students in school number 2 that participated in this research study according to their race and ethnicity. There were 19 students in the experimental group and 15 in the control

School Number 3

School number 3 was located in Perrine, a suburb of Miami, Florida. The surrounding neighborhood had an average property assessment value of $90,000 to $375,000. This translated into 34.9% of the students receiving free or reduced lunch. The overall population of 3, 662 students in grades 9 through 12 was comprised of 9% White Non Hispanic, 40% Black Non Hispanic, 48% Hispanic and 3% Asian/Indian/Multiracial. At the time of the study 15.7% of the students were serviced by Exceptional Student Educational (ESE) programs and received support services. 5.9% of the students were considered Limited English Proficiency Students (LEP) (School Information, 2007). Table 6 presents the number of students that were in school number 3 according to their race and ethnicity as well as the number of students and the percentages of each group.

The faculty and staff at school number 3 were 36% White, 30% Black, 32% Hispanic and 2% Asian/Indian/Multiracial. Thirty three percent of the instructional staff had a Master's degree, 9% had a Specialist degree and 0.3% had Doctoral Degrees. Within the Math Department 60% of the teachers were male and 40% were female, 28% were Black Non Hispanic, 36% were White Non Hispanic and 32 % were Hispanic, and 58.6% of the mathematics faculty had obtained graduate degrees (School Information, 2007).

Table 7 reflects the percentages and the number of students that were in school number 3 that participated in this research study according to their race and ethnicity. There were 16 students in the experimental group and 16 in the control.

Table 6
Demographics of School Number 3

Race/Ethnicity	Number of Students	Percentage
White (Non Hispanic)	330	9%
Black (Non Hispanic)	1465	40%
Hispanic	1757	48%
Asian/Indian/Mixed	110	3%
Total	3662	100%

Table 7
School Number 3: Demographics of Students Involved in the Study

Race/Ethnicity	Percentage	Number of Students
White (Non Hispanic)	5%	2
Black (Non Hispanic)	32%	10
Hispanic	58%	19
Asian/Indian/Mixed	5%	1
Total	100%	32

Tests of Hypotheses

A total of 51 GSP taught students (experimental group) that agreed to participate in this study, and 46 of the students completed the study. Four of the students that originally agreed to participate transferred to other schools, and one of the students moved out of the state of Florida. A total of 57 non-GSP trained students (control group), that agreed to participate in this study. However, only 50 completed the study due to transferring to other schools or moving out of the area. One of the control group students simply did not take the FCAT examination. It should be noted, however, that the student in question had very sporadic attendance, and the teacher noted that the student probably missed more days out of school than she spent in school. There were 21 boys and 25 girls in the experimental group. There were 23 boys and 27 girls in the control group.

Descriptive Statistics

Table 8 presents the descriptive data for the developmental scores of students in the experimental and control groups.

Table 8
*Descriptive Data for FCAT Mathematics Test Scales by Treatment Group **

	Prior Year		Current Year	
FCAT Scale	Experimental	Control	Experimental	Control
Number Sense	5.37 (2.49)	5.65 (2.71)	5.22 (2.41)	4.02 (2.99)
Measurement	3.87 (2.02)	3.53 (1.99)	4.98 (2.55)	3.68 (1.79)
Geometry	4.35 (2.08)	4.24 (2.18)	4.65 (2.01)	4.48 (2.01)
Algebraic Thinking	5.28 (2.73)	5.45 (2.94)	6.35 (2.84)	4.52 (2.44)
Data Analysis	5.24 (2.68)	5.82 (2.64)	5.00 (2.37)	3.44 (2.01)

Note: * Numbers in parentheses are standard deviations.

Hypothesis #1 - Students taught mathematics using GSP will score higher on the FCAT mathematics test than students who do not use GSP.

Multivariate analysis of covariance was used to test differences between the control and experimental groups on a canonical function composed of the FCAT scores of students on the five strands of the test using a similar function made up of their FCAT mathematics scores on the same strands in the previous year as the covariate. Significant differences were found between the groups at the $\alpha = .05$ level of significance, $\Lambda(5, 78) = .773$, $p = .001$. One-way analysis of variance indicated that there were differences by treatment for all FCAT mathematics strands except geometry as shown in Table 9.

Table 9
One-Way ANOVA Results for Treatment Differences of FCAT Scales

FCAT Scale	Adjusted Means: Experimental	Control	*F*	*p*	η^2
Number Sense	5.27	4.03	8.09*	.005	.08
Measurement	4.91	3.78	7.15*	.009	.07
Geometry	4.63	4.53	0.07	.797	.00
Algebraic Thinking	6.40	4.55	19.14*	<.001	.17
Data Analysis	5.13	3.39	39.03*	<.001	.19

Note: *$p < .05$

Hypothesis #2 - There is an interaction between the use of GSP and the sex of students in determining their FCAT mathematics scores.

Table 10 presents the descriptive data for the developmental scores of boys and girls in the sample. Multivariate analysis of variance showed no significant interaction between gender and treatment at the $\alpha = .05$ level of significance, $\Lambda(5, 78) = .993$, $p = .990$.

Table 10
Descriptive Data for FCAT Mathematics Test Scales by Treatment Group *

FCAT Scale	Prior Year		Current Year	
	Experimental	Control	Experimental	Control
	Boys (n = 43)			
Number Sense	5.43 (2.38)	5.50 (2.41)	5.19 (2.60)	3.91 (2.45)
Measurement	3.71 (1.93)	3.82 (1.84)	5.48 (2.58)	3.95 (1.70)
Geometry	4.38 (2.13)	4.18 (1.82)	4.52 (2.14)	4.41 (1.94)
Algebraic Thinking	5.14 (2.99)	4.73 (2.33)	6.24 (3.11)	4.32 (2.17)
Data Analysis	5.33 (2.96)	5.45 (2.63)	5.00 (2.61)	3.32 (2.06)
	Girls (n = 52)			
Number Sense	5.32 (2.63)	5.78 (2.97)	5.24 (2.30)	4.22 (1.97)
Measurement	4.00 (2.12)	3.30 (2.11)	4.56 (2.50)	3.52 (1.85)
Geometry	4.32 (2.08)	4.30 (2.46)	4.76 (1.94)	4.59 (2.12)
Algebraic Thinking	5.40 (2.55)	6.04 (3.28)	6.44 (2.65)	4.81 (2.60)
Data Analysis	5.16 (2.48)	6.11 (2.65)	5.00 (2.20)	3.67 (1.92)

Note: * Numbers in parentheses are standard deviations.

Hypothesis #3 - There is an interaction between the use of GSP and the SES of students in determining their FCAT mathematics scores.

Table 11 presents the descriptive data for the developmental scores of students receiving free or reduced lunch (low socioeconomic status students) and those not receiving free or reduced lunch (middle SES students) in the sample. Multivariate analysis of variance showed no significant interaction between participant socio-economic status and treatment at the α = .05 level of significance, $\Lambda(5, 82) = .898$, p = .127.

Table 11
Descriptive Data for FCAT Mathematics Test Scales by Socioeconomic Status *

FCAT Scale	Prior Year Experimental	Prior Year Control	Current Year Experimental	Current Year Control
Middle Socioeconomic Status (n = 53)				
Number Sense	5.31 (2.51)	5.56 (2.65)	5.58 (2.49)	4.26 (2.49)
Measurement	3.81 (1.92)	3.41 (1.80)	5.65 (2.56)	3.96 (1.87)
Geometry	4.54 (1.99)	4.30 (1.73)	4.62 (1.79)	4.59 (1.87)
Algebraic Thinking	5.08 (2.51)	5.37 (2.79)	6.46 (2.79)	4.67 (2.32)
Data Analysis	5.42 (2.47)	5.63 (2.63)	5.46 (2.49)	3.70 (1.98)
Low Socioeconomic Status (n = 43)				
Number Sense	5.45 (2.52)	5.77 (2.83)	4.75 (2.29)	3.74 (1.82)
Measurement	3.95 (2.19)	3.68 (2.23)	4.10 (2.32)	3.35 (1.64)
Geometry	4.10 (2.22)	4.18 (2.67)	4.70 (2.32)	4.35 (2.19)
Algebraic Thinking	5.55 (3.03)	5.55 (3.28)	6.20 (2.97)	4.35 (2.60)
Data Analysis	5.00 (2.97)	6.05 (2.68)	4.40 (2.11)	3.13 (2.05)

Note: * Numbers in parentheses are standard deviations.

Power and Effect Size

McNeil, Newman and Kelly (1996) defined effect size as $f^2 = R^2/(1-R^2)$ Cohen (1977) defined a small effect size as $f^2 = .02$, a medium effect size as $f^2 = .15$ and a large effect size as $f^2 = .35$. In this study, the power of a statistical test was deemed sufficient if it could detect a false null hypothesis 80% of the time when there was at least a medium effect size. Power was calculated using the strategies suggested by McNeil et al. (1996).

Omnibus MANOVA

Bray and Maxwell (1985) defined an Omnibus MANOVA as the first step in a MANOVA procedure. They went on to state that the omnibus MANOVA null hypothesis was based on all of the groups having the same population mean on the dependent variables. Before testing the main effects and the interactions, the researcher determined if the overall MANOVA was powerful enough to avoid type II errors. In this study, the test of the omnibus MANOVA had a power of virtually .9999.

Main Effects

McBurney and White (2004) defined the main effects as the effect of the independent variable on the dependent variable when it averaged across all of the different levels of all the possible independent variables. In the present study, the power for the tests of the main effects was .29 for a small effect size, .96 for a medium effect size and .99 for a large effect size, as calculated by the researcher.

Interactions

Overton (2001) defined an interaction effect as group of effects that cannot be simply added together; because when the two variables came into contact with one another, sometimes a change affected one or both variables. In this study, for the two-way interaction, the powers were .17 for a small effect size, .87 for a medium effect size and .99 for a large effect size as calculated by the researcher (McNeil et al., 1996).

Summary

This chapter discussed the research questions, the research hypotheses, the demographics of the study and the data analysis. This chapter examined the MANCOVA analysis of the study to examine the strands of the FCAT to determine their contributions to this study. The following chapter will discuss the results of the study in detail and offer suggestions for future studies.

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

This chapter presents a discussion of the findings, conclusions, and limitations of the study. Recommendations for future studies are also presented.

Discussion of the Results

What is the effect of using GSP on the achievement of 10th grade geometry students?

The main purpose of this study was to determine if the use of GSP affected the FCAT results of students in 10th grade geometry. The results were mixed. This researcher was able to locate one study that related the use of GSP with increasing mathematics achievement (Dix, 1999). Dix studied two 8th grade classes in Australia. The Dix (1999) study showed that the use of GSP did not increase students' mathematical abilities on a test that measured students' knowledge of tessellations and angle sums. Dix used "The Standard Progressive Matrices Test" (Raven, 1960) to pre- and post-test 8th grade students' mathematics achievement in an experimental and control group. Dix's results revealed a significant difference on the pre- and post-test scores of the students using GSP over those that did not. The present study investigated the use of GSP in relation to geometry students' achievement on the mathematics portion of a high stakes high school exit examination (FCAT). Three 10th grade geometry classes were in the experimental group that used GSP and 10th grade students from three other geometry classes that did not use GSP were in the control group. Like Dix's study, the present study revealed a significant difference in FCAT achievement between the experimental and control groups.

The effect of the use of GSP on the 10th grade students was significant as the MANCOVA results showed. The MANCOVA results revealed a p-value = .001, or as stated in other words: Technology, particularly GSP, had a positive effect on the FCAT results of the experimental versus control group. This result was important because it showed that the use of GSP helped to improve FCAT mathematics scores. Usiskin (1982) stated that the Van Hiele levels of geometric thought are a measure of geometry achievement. This researcher decided to look at studies that correlate the use of GSP with Van Hiele levels. Choi-Koh (1999) stated that through the use of GSP he was able to increase a single student's Van Hiele level by two levels, or in other words, that student's knowledge in geometry grew considerably. Interestingly, although the present study revealed significant differences in overall FCAT scores of the experimental group versus the control group, no significant difference existed between the geometry strand scores of the students that received the GSP treatment and the students that did not. This study examined the effects of the use of GSP on students' FCAT mathematics scores.

The scores on the geometry strand did not reveal a significant difference, the scores in the other four strands (number sense, measurement, algebraic thinking, and data analysis) did. It should be noted that the measurement strand of the FCAT includes perimeter, area, volumes and surface areas. It should be noted that GSP has dynamic properties as it is designed to assist students with the measurement strand as well. Students are able to use GSP to find and explore perimeters, areas, volumes and even surface areas. Further research needs to be conducted to determine exactly how and why GSP affects other strands.

The teachers in this study taught both classes using the training that they received at a GSP summer in-service workshop. Although the students in the control group were not exposed to the GSP treatment, the training that the teachers received facilitated their teaching mathematics generically and helped the teachers to equalize the level of instruction and therefore improve the effectiveness of their instruction. GSP is an extension of the compass and straight-edge. In other words, the methodology that is used to draw a figure using a compass and straight-edge with a paper and pencil is similar to the methodology that GSP uses to draw a figure except the drawing is done using the GSP software program (Abu-Mosa, 2009). Although both classes improved their post-treatment FCAT scores, the class that received the GSP had higher overall scores.

How did the achievement of boys and girls in a 10th grade geometry class compare as a result of the use of GSP?

An analysis of the interaction between the gender of the students and the use of GSP on the FCAT mathematics scores revealed some promising results. The calculated MANCOVA p-value = .060, means that there was no significant difference between the FCAT mathematics scores of the boys and the girls. This result is important because previous studies that compared the mathematics achievement of girls and boys stated that boys mathematically outperformed girls in high school.

Rebhorn and Miles (1999) stated that boys scored significantly higher than girls on standardized tests, and that as boys and girls progressed through high school, the advantage that boys exhibited grew. The findings of the present study revealed that there were no significant differences between the FCAT mathematics scores of the boys and the girls when GSP was used. However, when the covariate data were analyzed, a significant difference between the boys and the girls on the previous year's FCAT favoring the boys was found. The post-treatment FCAT scores did not yield similar results.

Does the use of GSP close the achievement gap between boys and girls in high school mathematics? This cannot be determined through this study. This is a single isolated case with a small diverse population of students that are located in one of the southern most cities in the state of Florida. It cannot be stated that the use of GSP closed the achievement gap between the boys and the girls in this study because the interaction between the use of GSP and the gender of the students was not significant.

Further research on this matter is needed. It needs to be discovered why the FCAT mathematics scores of the girls and boys were not significantly different. It needs to be stated that the boys had higher FCAT mathematics mean scores than the girls; however, the results were not significant. An examination of the students' FCAT mathematics scores showed that although the boys had higher overall mean scores the FCAT mathematics scores of the girls showed a greater increase from the previous year.

Tiedemann and Steinmetz (1997) stated that boys were more logical than girls, and because of this, they were better able to think mathematically than girls. They believed that once boys and girls attend high school, the mathematical knowledge of the girls begins to decrease and the mathematical knowledge of the boys begins to surge ahead. The present study did not confirm those results. Although the boys scored higher than the girls on the FCAT mathematics examination, the results comparing the differences between the sexes were not significant when comparing the boys versus the girls in the experimental and control groups.

What is the effect of the use of GSP on the mathematical achievement of low socio-economic status (based on free and reduced lunch) 10^{th} grade geometry students?

Ogwu (2004) stated that higher SES children have a built in advantage over lower SES children. He stated that higher SES students have parents that have access to greater resources and therefore can hire mathematics tutors and purchase the latest software to assist their children. The present study was able to allow all of the students in the experimental group access to the computers that were loaded with the GSP software, thereby opening access to the GSP technology to all experimental group students regardless of SES.

Lubienski (2007) stated that low-socio-economic students in high school mathematics score lower in mathematics assessments than their high socio-economic counterparts. She believed that lower SES students did not have the same qualification and were lacking in the skills needed to surpass higher SES students in mathematics. In her study, the high SES students scored over 26 points higher on the NAEP mathematics assessment than their low SES counterparts.

In the present study, when the statistical analysis was conducted to determine if a difference existed in the FCAT mathematics scores of low and high SES, the MANCOVA p-value = .102. This meant that no significant differences existed in the FCAT mathematics scores of the low and high SES students when comparing the experimental versus the control group. When the adjusted mean scores (covariates) of the dependent variables were analyzed, it was revealed that the students that paid full price for their lunch outscored the students that received free or reduced lunch on all five of the dependent variables (number sense +.831, measurement +1.156, geometry +.127, algebraic thinking +.396 and data analysis +.823). Although the high SES students outperformed the lower SES students on all five strands of the FCAT, the multivariate results did not reveal a significant difference in the scores. In other words, there was no significant difference between the scores of the two groups when comparing the students in the control versus the experimental groups. This result suggests that the use of GSP did not affect the achievement of the low SES students differently from the of the high SEs students..

Discussion of the Multivariate Results

Analysis of the multivariate results revealed some surprising conclusions. The overall FCAT score demonstrated significant differences between experimental and control groups. Interestingly, the scores for the geometry strand did not demonstrate a significant difference between the experimental and control groups. Although the scores on the geometry strand were not significantly different, the scores on the other four strands (number sense, measurement, algebraic thinking, and data analysis) did demonstrate a significant difference favoring the experimental group. It should be noted that the measurement strand includes some geometric concepts. The measurement strand includes concepts such as area, volume, and perimeter (FDOE, 2009). This suggests looking more closely at the mathematical ideas within each strand in contrast to the opportunities for learning these ideas that may be afforded through the use of GSP.

The number sense strand measures students' understanding of rational and irrational numbers, sequences and series, estimation strategies, structures of complex number systems, real number systems, representing numbers in a variety of ways and concrete and symbolic representations of numbering systems. The measurement strand focuses on students' understanding of the use of concrete and graphic models to derive formulas for finding perimeters, areas, volumes, surface areas, distance, time, angle measures, similarity, proportionality in real world situations, direct and indirect methods of measuring, rated measures (mph, f/s, yards per day, etc…), and levels of accuracy and precision. Proportionality was covered in multiple strands. In the geometry strand, proportionality was focused on with similar triangles. In the measurement strand, proportionality was used to find the missing sides of different figures. In the algebraic strand, proportionality was used to discover heights of people and objects, as well as in the study of slopes of linear relationships (FDOE, 2009).

The algebraic thinking strand is focused on describing, analyzing and generalizing relationships, patterns and functions, determining the impact when changing the parameters of a function, representing real world situations using finite graphs, and using systems of equations and inequalities to solve real world problems (FDOE, 2009). The data analysis strand included interpretation of data that has been collected, organized and displayed in charts, graphs and tables, calculated measures of central tendency like means, medians, modes and range, making predictions on larger populations from smaller samples, determining probabilities for simple and compound events, designing and performing real world statistical experiments, determining independent and dependent events, using tree diagrams, permutations and combinations and explaining the limitations of using statistical techniques and data in making inferences (FDOE, 2009). The geometry strand included using properties and relationships of geometric shapes to perform formal and indirect proofs, examining relationships of cross-sections, using coordinate systems for graphing, verifying properties of two and three dimensional shapes, calculating distances, midpoints, slopes parallelism and perpendicularity, and examining tangency, reflections, symmetry, transformations like flips, turns and slides (FDOE, 2009).

McClintock, Jiang and July (2002) determined that through the use of GSP a group of high school students increased their Van Hiele levels by two to three levels. They showed how GSP helps students to learn geometry in a more dynamic way and how GSP makes learning mathematics exciting. The present study was concerned with the effects that the use of GSP had on students' FCAT mathematics achievement scores. However, since all of the students in the study were in geometry classes, it was thought that the students' geometry strand scores would be significantly affected by the students' use of GSP.

In the present study, when the students' scores within each FCAT strand (number sense, measurement, geometry, algebraic thinking, and data analysis) were statistically analyzed, the results were most interesting due to the fact that the scores in the geometry strand did not reveal a significant difference between the experimental and control groups. This researcher hypothesizes that although GSP was only used with the experimental group both groups benefited because the same skills that are used to teach drawing shapes and reasoning about shapes using GSP are directly related to the methods used to teach drawing shapes and reasoning about shapes using a compass and straightedge. It is possible that the teachers indirectly transferred approaches to drawing and reasoning about geometric shapes and ideas from their GSP training to the control group through the methods that they used to teach geometry in both the control and experimental groups. The goal of both groups (experimental and control) was to learn geometry through discovery.

As previously noted, the students' measurement strand scores were significantly different between the experimental and control groups and that strand includes mathematics topics such as area, volume, perimeter and angle measurements taught in high school geometry. The geometry strand focuses solely on geometric concepts such as perpendicularity, parallelism, ratios, proportions, coordinate systems, geometric properties and geometric applications (FDOE, 2009). Groman's (1996) work supports the findings from the present study regarding the significant difference between experimental and control groups on students' FCAT scores within the measurement strand. Gorman stated that through the use of GSP her students were able to get a better understanding of what happens when you manipulate figures and change features of objects like length, width, areas and volumes. In the present study, students in the experimental group scored significantly higher than the students in the control group on the measurement strand, which included concepts related to length, width, area and volume,.

It may not definitively be inferred that scoring higher on the measurement strand is due to the use of GSP. However, the use of GSP may impact students' measurement strand scores, because students that use GS can learn about area, volume, perimeter and angle measurements. Given the content of the measurement strand, the measurement strand FCAT items may have been directly related to what a student can learn through the use of GSP. Alternately, other factors can contribute to a student performing well on certain parts of a test such as the measurement portion: the student may have concentrated on one thing more than another or the teacher may have focused more on one thing than another. However, the use of GSP should be considered as a factor that assisted the students in the experimental group on the measurement strand items of the FCAT.

Usiskin (1997) stated that algebra was a unique language. He believed that in order to speak algebraically there were five components that needed to be understood. Those five components were:

1. Understanding relationships
2. Knowing how to observe and analyze differing patterns
3. How to solve and understand unknowns, sometimes called variables
4. How to use formulas to solve and understand problems
5. Understanding placeholders

Using GSP allows students opportunities to write about their findings and observe unique relationships that occur when analyzing patterns, to solve problems involving unknown widths, lengths, areas, volumes, to make conjectures, to prove or disprove theorems, to better understand relationships, to look at objects from different angles and to solve word problems of all types by turning the words of a problem into a real picture that can be manipulated with the click of a mouse. These opportunities provided by GSP were aligned with aspects of mathematics content in the algebraic thinking strand of the Florida Sunshine State Standards that are measured by the FCAT. Due to this alignment between possible uses of GSP and the content of the algebraic thinking strand assessed with the FCAT, the use of GSP may have contributed to the experimental group scoring significantly higher than the control group in the algebraic thinking strand.

Lewis-Beck (1995) stated that data analysis consists of transforming data, gathering and modeling data with the purpose of finding information that was desired, finding information to support the conclusions, and being able to make the proper decisions. Similarly, the data analysis strand of the Florida Sunshine State Standards included collection, organization, analysis and interpretation of data using charts, graphs and tables, making predictions from samples, determining independent and dependent events, and making inferences from data (FDOE, 2009). Through the use of GSP, students have opportunities to develop these mathematical ideas from the data analysis strand. These opportunities may have contributed to the experimental group's higher achievement on the data analysis strand of the FCAT in comparison to the control group. This study does not suggest that the use of GSP is the sole reason why the experimental group significantly outperformed the control group on the data analysis strand; however the results leads in the direction that GSP may have contributed to the higher scores on the data analysis strand for the experimental group due to ways that students can collect, organize, manipulate and interpret data while using GSP.

There were various reasons to explain the significance differences between the experimental and control group FCAT scores on the four strands, other than the geometry strand. As discussed above the use of GSP by the experimental group may have contributed to the higher scores in these strands. Additionally, the students in the experimental group may have had additional or outside tutoring that enhanced their learning related to these strands. The significantly higher achievement of the experimental group in comparison to the control group on the four FCAT strands, other than the geometry strand, suggests possible directions for further research on the use of

GSP to improve students' development of algebraic thinking, data analysis, number sense and measurement. For example, since the measurement strand included some geometric concepts, the use of the GSP likely helped to increase the experimental group's FCAT scores in that strand, a finding aligned with the work of Gorman (1996). Other students can investigate the possible influences of the use of GSP on students learning of other mathematics ideas assessed on the FCAT.

Just as there are reasons why the students in the experimental group significantly outperformed the students in the control group on the four FCAT strands other than geometry, there are also reasons why the experimental group might not have outperformed the control group on the geometry strand. In the Florida Sunshine State Standards, the geometry strand included using properties and relationships of geometric shapes to perform formal and indirect proofs, examining relationships of cross-sections, using coordinate systems for graphing, verifying properties of two and three dimensional shapes, calculating distances, midpoints, slopes parallelism and perpendicularity, and examining tangency, reflections, symmetry, transformations like flips, turns and slides (FDOE, 2009). These mathematical ideas may have been taught in both experimental and control groups using similar strategies that did not involve GSP or approaches to teaching these ideas through exploration and discovery may have been used effectively in both experimental and control groups. Additionally, the FCAT was completed in the beginning of March and these geometric ideas may have been focused on more directly between March and June when the school year ended. Further research should be conducted to investigate students' use of GSP on their understanding of the mathematics topics in the geometry strand of the FCAT.

Conclusions

The use of GSP was shown to assist the students in the experimental group to outscore the students in the control group in their overall scores on the FCAT. Through the use of GSP the boys in this study did not significantly out score the girls on the mathematics portion of the FCAT. Through the use of GSP the students that high SES did not significantly out score low SES students even when the results were adjusted for the covariate.

The results of this study suggest that the use of GSP may help students to score higher on the FCAT. This researcher cannot say that the use of GSP helped all of the students in the experimental group to outscore the students in the control group on the mathematics portion of the FCAT. However, there was a significant difference in the mathematics scores favoring the experimental group. The overall FCAT scores and the scores for each of the strands, with the exception of the geometry strand, revealed significant differences favoring the students using the GSP.

Limitations

There are several limitations to this study that need to be discussed. The sample size is an issue of this study. The small sample size (less than 100) may have skewed the results in a way that has yet to be explained, although the power of the test was shown to be sufficient.

The population of students that participated in this study was diverse and may not mirror all the groups of students residing across this nation and other nations. In some places in the United States of America there is very little diversity among the students. In some countries in the world, there is very little diversity among the students. The results of this study may not be generalizable.

Ideally, all of the teachers that participated in this study received the same training. Some teachers may have had previous experience with the use of GSP and therefore had an unfair advantage over the teachers that saw GSP for the first time during the training session. Although the control group did not receive the GSP treatment, their teacher may have implemented methods of teaching similar to those used with teaching with GSP however, without using the software directly. The same teachers taught both classes.

Recommendations for Future Research

Future studies should focus on what is it about GSP that caused the unintended results that were discussed in the response to research question number one. Why was the geometry strand of the FCAT mathematics test not significant in the multivariate results and the other four strands were significant? Should GSP be used in algebra classes, due to the fact that this study showed that the use of GSP helped to increase the algebraic thinking strand?

Future studies should concentrate on finding larger groups to participate in similar studies. Larger sample sizes may bring more accurate results and thereby remove any doubts that may exist concerning the results of the present study, particularly the significant differences in scores between the students using GSP and those that did not use it. Future studies should examine how the use of GSP may assist in closing achievement gaps in gender and SES. If GSP can be used to close the wide open gaps between the sexes and between students of low and high SES in mathematics, then this could be an opening that present and future generations can use to create a level playing field for all students to succeed.

Summary

This chapter discussed the MANCOVA results of this study, the multivariate results, the conclusions, the limitations and the recommendations for future studies. This study produced mixed results on the issue of GSP being an effective treatment for increasing the FCAT scores of students. The difference on FCAT scores between the experimental and control groups was significant. However, the multivariate analysis of the data demonstrated some unexpected results. Of the five strands tested on the FCAT (number sense, measurement, geometry, algebraic thinking and data analysis), all of the strand scores except for the geometry strand revealed significant differences between the control and experimental group, favoring the students using the GSP . This opens the door to determine if GSP has unintended consequences.

When an analysis was conducted to determine if significant differences occurred between the boys and the girls as well as the high and low SES students the results were insignificant. Past studies like Lubienski (2007), Benbow and Stanley (1983) and Cherian (1994) previously stated that boys outperform girls in higher level mathematics and that high SES students are far superior mathematically to their low SES counterparts. The present study did not replicate those results. However, it should be noted that in both cohorts the boys did score higher than the girls and the high SES students scored higher than the low SES students on the mathematics portion of the FCAT, their results were not wide enough to be considered significant.

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