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Attitudinal Study: The Interaction of Students Taking Calculus and Prerequisite Courses while Participating in Peer Tutorials

Deborah Coleman Hannah

ACCEPTANCE

This dissertation, ATTITUDINAL STUDY: THE INTERACTION OF STUDENTS TAKING CALCULUS AND PREREQUISITE COURSES WHILE PARTICIPATING IN PEER TUTORIALS, by DEBORAH COLEMAN HANNAH, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Education, Georgia State University.

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ABSTRACT

ATTITUDINAL STUDY:
THE INTERACTION OF STUDENTS TAKING CALCULUS AND PREREQUISITE COURSES WHILE PARTICIPATING IN PEER TUTORIALS
by
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Bridging the achievement gap while improving overall performance in high school mathematics is a primary concern in the educational arena. A peer tutoring strategy was implemented to examine its effects on the achievement and attitude of African American students in mathematics courses. Vygotsky's theory of social interaction and the Zone of Proximal Development served as the guide for this investigation involving 138 high school students. Dyads were formed by pairing 46 Algebra and Geometry students with 46 Advanced Placement Calculus students for after- school tutorial sessions. Forty-six members of a control group received no tutoring intervention. Participants completed a 25-item graduation pretest and a 31-item Mathematical Disposition Survey (Donovan & Beveridge, 2004). No significant group differences were found on any pretest measures.

After working with trained tutors for six weeks, the tutees completed a posttest and survey. Students' course grades from the first week were compared to their grades at the conclusion of the study. ANOVA indicated achievement margins were statistically significant at the .05 level; however, attitudinal changes were not significant. Results indicated that participation in peer tutorials appears to have a predictive effect on increased achievement, but not on student attitudes toward learning mathematics.

ATTITUDINAL STUDY:THE INTERACTION OF STUDENTS TAKING CALCULUS AND PREREQUISITE COURSES WHILE PARTICIPATING IN PEER TUTORIALS

by

Deborah C. Hannah

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In loving memory of Larry James Coleman

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CHAPTER 1

INTRODUCTION

Peer tutoring is being used increasingly across various disciplines to help engage students in their own learning process (Mehra & Mondal, 2005; Topping, 2003; Mastropieri, Scruggs, Spencer, & Fontana, 2003; d'Arripe-Longueville et al, 2002; Gabriele & Montecinos, 2001; Matthews, 2001). When students actively participate in learning activities especially with other students, both teachers and students alike reap the benefits as more time is spent on task (Tinto, 1997). Concernment at all levels of schooling fosters attainment. According to Shapiro and Levine (1999), educational outcomes correlate with student engagement. Therefore, when students are actively engaged in their learning, the likelihood that they will perform better increases. There is a need to improve student performance in mathematics, and this study explored peer tutoring as a vehicle for doing so.

This study examined peer tutoring as a potential enhancement to the learning process. A public high school in the southeastern United States of America with a population of approximately 2200 students served as the research site for the study. The investigation focused on the attitudes of the tutees following their interaction with peer tutors during after school tutorial sessions. Achievement margins were also scrutinized following the intervention. The process afforded students enrolled in Algebra and Geometry courses the opportunity to receive instruction from Advanced Placement (AP) Calculus students.

Participants were studied within the school environment in a naturalistic setting that was uninterrupted by the principal investigator.

Research has shown that implementing peer tutorials will promote student engagement and improve academic skills (Benard, 1999; Kalkowski, 1995; Martino, 1993; Miller et al, 1993; Topping, 1988). Enhancing skills in mathematics courses was one aim of the tutorials. If students' skills improve and they remain engaged for longer periods, then their mathematics comprehension should improve which paves the way to gains in achievement. The initiation stage of peer tutoring is not overly complicated or time consuming. Given administrative approval and manageable numbers of willing participants, the process of implementing a peer tutoring program can be accomplished quickly and with relative ease (Maheady et al, 1996). Also, there are numerous benefits that can be associated with peer tutoring that relate to attitude and achievement. Therefore, peer tutoring was selected as the method of choice for the intervention.

Additionally, Greenwood, Carta, and Hall (1988) found that not only does peer tutoring address performance and achievement but also discipline. Peer tutoring structures lower the incidence of misbehavior in classrooms. They further suggested that students with behavior problems may serve as either tutors or tutees and that when students are engaged in learning activities they are less likely to cause disruptions. It was anticipated that discipline would improve in the study, but in an indirect manner since the tutoring would not occur during class time but rather outside of class. However, one aim of the investigation was for participants that were involved in tutoring activities to remain on task for longer periods of time during classroom instruction and as a result, reach a higher level of understanding in mathematics.

In addition to affecting changes in mathematical performance, the interaction during peer tutorials can impact students attitudes toward learning (Topping , et al, 2003; Valeski & Stipek, 2001). Tutoring contributes to improvement in students' attitudes about school, which in turn reduces drop out rates, truancies, and tardies (Cohen, et al, 1982; Kalkowski, 1995; Martino, 1993). Research also supports that tutoring leads to an increase in students' self-esteem and confidence (Kalkowski, 1995; Gaustad, 1992) and promotes social skills by breaking down barriers and creating new friendships (Miller, et al, 1993; Kalkowshi, 1995). Additionally, peer tutoring provides emotional support and positive role models (Martino, 1993) .

It is not surprising that many teenagers are prone to peer influence (Rubin, Bukowski, & Parker, 1998). The phrase "peer pressure" is used repeatedly in reference to high school children. In implementing the intervention, it was taken into account that this influence exists among teenagers and is often powerful. Peer influence was explored within the African American culture for this population of students. Attitudinal changes towards learning mathematics was studied in African American teenagers as they participated in peer and cross-age peer tutorials.

Statement of the Problem

The notion of bridging the achievement gap causes mathematical performance in the United States among students of color to be a major concern. Proportions of academic underachievement among African American youths are rising (Gonzales, et al, 1996), and models of motivation and achievement have failed when applied to African American

children. According to a study conducted by Henningsen and Stein (1997), a predominant influence in student engagement and completion of learning tasks is the appropriateness of the amount of time allotted for the task. Although it may be needed, the proper amount of teacher time is not always possible. More needs to be done to reach out to students who require assistance. Many teachers offer after school tutorials; however, obstacles hinder some populations from attending. It is often problematic for those who require the most help to attend the sessions and get the necessary assistance they require to be more successful. Peer tutoring was investigated as a potential solution to this problem. The efforts of the investigation were concentrated within two important areas of concern for today's high school mathematics students: attitude and achievement. By channeling efforts in these areas, it is possible to diminish the problems students and teachers face. Many studies report that students' attitudes can be influenced and their performance improved through peer tutorials (Gaustad, 1992; Topping, et al, 2003; Topping & Bamford, 1991; Cohen, et al, 1982). Enhanced attitudes, performance, and achievement can be accomplished by utilizing peers as tutors to encourage and maintain student engagement. There are two ways that peer tutoring can be implemented to reduce classroom problems. Students can be paired to work together during class or they can be encouraged to work together outside of class. The focus of this study was on the effects of student interaction during peer tutorials which took place outside of the regular classroom setting. In either case, tutors can provide reinforcement for teachers by interacting with other students one-on-one in a more personal manner. Peers can tutor each other at home, the community center, or a local library.

Purpose

The purpose of this study was to search for educational improvement in the subject of mathematics. Educational systems are imperfect, and as such are constantly in need of re-evaluation. Major changes in how our children are educated within the United States are eminent. Not only are federal, state, and local agencies undergoing revisions, but individuals who are dedicated to the teaching profession are also searching for remedies for the numerous difficulties faced in educating students (McLaughlin & Shepard, 1995; Genovese, Hursh, Jitendra, and Lupton, 2005). Towards this end, the main goal of this study was to ascertain to what extent peer tutoring impacts the attitudes and performance of students studying Geometry and Algebra in a public high school.

Mathematics scores are declining on standardized tests at many high schools. Furthermore, too many students appear unconcerned and exhibit negative attitudes towards learning in general and learning mathematics in particular. Many students enrolled in algebra and geometry courses at the research site have below average scores. To perform better in mathematics, students can get help from their peers who are more capable. Tutoring sessions will cause the students to interact academically as well as socially. The results of such interaction should have a positive effect on either the achievement or the attitude of the learner, or possibly both. Positive attitudes towards mathematics lead students to be more receptive to learning and make teaching seem less of a challenge. Due to the many benefits associated with peer tutoring, this is the method that was selected for this investigation. The effects of peer tutoring were

examined on two different perceptions of peer interaction: 1) mathematical performance on assigned tasks and 2) attitudinal changes of students toward their learning experiences. This investigation was carried out to identify peer tutoring as a remedy for some of the challenges that students and teachers encounter such as failing grades in mathematics and poor attitudes towards learning experiences.

Research Questions

The overall question guiding this study was "What are the effects of students' interactions during peer and cross-age peer tutorials on student attitudes towards learning mathematics?" The specific questions addressed in this study were as follows:

1. What is the difference in the mathematical achievement of students participating in peer tutorials and students who are not being tutored?
2. In what ways does tutoring by a peer impact an individual's attitude towards engaging in mathematical learning activities?

Rationale

Many new innovative approaches have been researched and added to the arsenal of tools with which educators can instruct their students on all levels. One of the most useful and efficient may be the use of peer tutors. Peer tutoring is easily implemented and cost effective (Berliner & Casanova 1988; Early, 1998). The benefit of this type of educational intervention is two-fold. Not only will the students receiving tutoring be helped but the tutors also benefit from the tutorials. Tutors have the opportunity to review and refresh some of the basic mathematical concepts that may not have been currently in

the forefront of their minds. They can relearn and reinforce their understanding of basic mathematical concepts by tutoring their fellow classmates and they feel needed. It can be argued that it is the tutors who reap the highest benefits from peer tutoring (King, 2002; Falchikov, 2001), and studies have shown that the attitudes of tutors may likewise be affected during the intervention (Cohen, et al, 1982; Topping, et al, 2003). However, the scope of this study was limited to the effects of the intervention on the tutees not the tutors.

Peers have the power to significantly influence one another in positive ways. Pairing students for educational support tends to raise mathematics proficiency levels on a broad scale (Topping, 2003). Broadening educational opportunities for every student should have the effect of producing young minds which are mathematically and technologically prepared to lead us into the new millennium. While other content areas may also be improved through this procedure, mathematics is the subject of this researcher's experience and expertise. As stated by Topping (1991):

> Cross-age peer tutoring should prove an excellent mechanism for facilitating social interchange and growth between members of a school. . . From the tutees point of view, being a "friend" of a high-status older child is likely to enhance the youngster's self-esteem. Children are extremely important to children, and this may be particularly true as they approach and enter adolescence, and retreat from the influence of parents. The peer tutorial relationship has few of the institutional and authoritarian overtones of relationships between professional teachers and children. (p. 3)

Encouraging students to work cooperatively with one another may help strengthen their intellectual abilities as well as their resolve. Also, for areas with transient populations of students, initiating tutorial programs in schools could ease the adjustment period as students transfer to a new school or learning environment.

Significance

Today, schools around the nation serve populations that are vastly different from those encountered a decade ago. The Nation's Report Card clearly shows that minority populations have shown gains in mathematics scores in recent years (Lee, 2007). Yet, my search of the literature revealed relatively few studies that were conducted involving African American students enrolled in high school mathematics courses. This study is significant because the participants are predominantly African American high school students. Furthermore, the study took place within the community and examined the performance and attitudes of these students as they interacted with their peers.

Understanding the African American culture as it relates to education can enhance policy-making and practice (Freeman, 1998). In this particular school environment where the population of students enrolled in Algebra and Geometry is 90% African American, using peers as tutors will maximize the learning potential by recognizing and incorporating the strength of the culture of African American children into the learning process (Hale-Benson & Hilliard, 1986). As they participate in the tutorials, student attitudes, comprehension, and performance in mathematics may be positively impacted.

Conceptual Framework

Since the connections between students and the effects of the tutoring intervention as it relates to learning situations is paramount, a discussion of variables which are attributable to learning is relevant. The research supports a bi-directional influence which exists for both tutors and tutees (Topping, et al, 2003; Cohen, 1986). This relationship is complex and must be clearly understood in order to obtain maximum benefits from the grouping process.

Emphasis on the learner and the interaction during peer tutorials provided the fundamental basis of this investigation. The intervention allowed learners the opportunity to interact with their peers to discover or reconstruct mathematical relationships in order to build their knowledge. This conversational theory of learning fits into the constructivist framework where emphasis is placed upon the learner as an active participant in creating meaning. The tutor's role was to carry out a dialogue which aided the learner in understanding the subject matter.

John Dewey's constructivist view emphasized the place of experience in education. In his view, education depends on action, and knowledge emerges only from situations in which learners must draw from experiences that have meaning and importance to them (Dewey, 1916). These situations occur in a social context, such as a classroom, where students join in creating a community of learners who build their knowledge together. If real growth is to occur, the learner must want to learn and be active in the learning process (Dewey, 1916). It is expected that students who volunteer to receive tutoring will fulfill Dewey's criteria. They want to learn and will actively participate in their learning process as they are tutored. Tutors will aid the tutees in building their knowledge of mathematics as they study together outside of class in a more relaxed social atmosphere.

Piaget demonstrated that children actively process material with which they are presented. Piaget's constructivism is based on his ideas of the psychological development of children. He saw discovery as the fundamental basis of learning: "To understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and

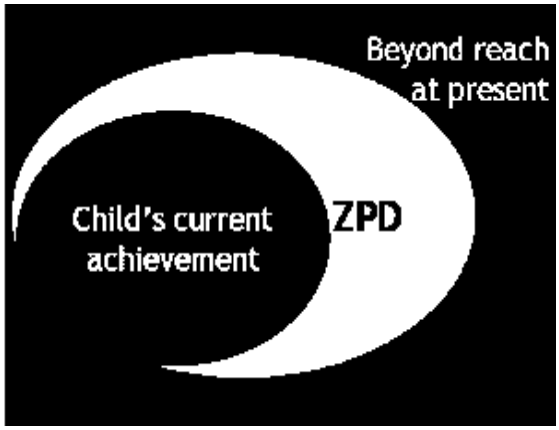
not simply repetition" (Piaget, 1973, p.20). Like Dewey, Piaget felt that children learn in classroom situations that involve activities of interest to them and understanding is built through active involvement.

Theoretical Framework

This research study was guided by Lev Vygotsky's ideas on the role of social interaction within learning environments. Vygotsky provided the most significant bases of social constructivist theory with the Zone of Proximal Development (ZPD). This theory holds that when children are tested on particular tasks, they perform better after working collaboratively than on their own. He contends that this is not always the result of being taught how to perform, but because the process of engagement allowed them to refine their thinking (Daniels, 1996). Vygotsky's theory on the ZPD was explored and used to investigate this student population through the implementation of an on-site peer tutoring program.

Vygotskian theory also adheres to the significance of dialogue as an avenue by which individuals negotiate conceptual change. The findings of Vygotsky lead us to believe that learning environments for children should involve guided interaction and they should change their conceptions through intelligent action, speech, and communication. For this reason, it is anticipated that students who are not performing well in mathematics due to misconceptions will show improvement upon being tutored by a peer who is a more skilled mathematics student. It is important that the peer tutor is capable of verbalizing the problem solving process to help with the tutee's understanding. Vygotskian theory further suggests that mature concepts are achieved through increased exposure to expert vocabularies through social interaction.

Figure 1. Vygotsky's Zone of Proximal Development lies between current and attainable understanding(Daniels, 1996).



In his words:

> In the development of the child is, that which should be realized at the end of the development, as the result of the development, already present in the environment from the very beginning onwards . . . the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined by problem solving under adult guidance or in collaboration with more capable peers." (Vygotsky, 1978, p. 178)

Vygotsky was proposing that children's understanding is not shaped merely by adaptive encounters with the physical world but through interactions between people in relation to a world that is cultural, meaningful and significant. He viewed human knowledge and thought as fundamentally cultural, and perceived that they were derived from the nature of social activity. (Edwards & Mercer, 1987).

The steps that were taken in the research process for this investigation were shaped by a socio-cultural view of student motivation within the domain of peer influence. Environment and culture were taken into consideration because the development of knowledge is affected by these influences. The learning process requires students to be

receptive, therefore environmental, physical, psychological and sociological factors all have an affect on students' readiness to learn. Although Vygotsky's theory is widely accepted, until now, it has not been tested in a high school setting using Advanced Placement Calculus students as the capable peers and students enrolled in the prerequisite courses leading to the Calculus as tutees.

Overview of the Methodology

Due to the nature of this investigation and the questions posed, a quantitative approach was most feasible for conducting this research study. Initially, current grades were inspected to look at student achievement in Algebra, Geometry, and AP Calculus. The number of students doing poorly in the subject were determined along with the number of students performing well in the course. These two groups were identified by using their grade point averages. F's were considered as poor grades and doing well was defined by A's on their transcripts.

In the next phase of the investigation, a list was compiled of AP Calculus students who were capable and interested in tutoring their peers in Algebra or Geometry (the prerequisite classes). Although some of the literature has shown that low-achieving students may be successful as peer tutors (Glesecke & Cartledge, 1993), the tutors within this study were chosen from high-achieving students. A list of the lower level students who express a desire to work with a tutor was also compiled. Upon perusal of these lists, it was determined how many one-on-one pairs were possible, which students were genuinely willing to work, and therefore should benefit most from having a personal tutor. The final decisions were based upon the number of permission forms returned and

results obtained from surveys coupled with the principal investigator's insight and knowledge of her students.

A Mathematical Disposition Survey (MDS), (Donovan & Beveridge, 2004) was administered to each participant along with a pretest composed of a practice high school graduation test. The surveys were designed to reveal students' feelings about mathematics. Once the prospective peer tutors and tutees were established, an informal meeting was set up after school for the pairs to meet and become acquainted with one another. The tutors were then trained with a qualified educator as outlined by Goodlad and Hirst (1989) and Rabow, Chin, and Fahimian (1999). They were required to familiarize themselves with the subject content and keep accurate records. During one week of training, tutors learned to establish a relaxed atmosphere and were instructed to help tutees at their instructional level without doing the work for them. Students of differing abilities (one upper level and one lower level) were paired with one another outside of class for tutorial sessions.

The expectation of the program was that tutoring would be ongoing and tutors as well as tutees would keep journals of their tutoring sessions. Regular monitoring by the mathematics educator took place to insure that the tutoring was implemented. Forty-six pairs of students (tutors and tutees) were purposefully selected for the investigation. However, pre- and post-intervention data was gathered only from the 46 students who were the tutees, and it was compared with the 46-member control group using ANOVA (analysis of variance). The results were organized, analyzed, interpreted, and represented in tables and graphs for a complete report of the data and findings of the researcher. The Mean Distance from Optimal (MDO), (Donovan & Beveridge, 2004) was used to

evaluate the data. A more in-depth discussion of methodology will follow in Chapter 3, but the overall process is outlined in the table which follows.

Table 1

Outline of Methodology

Questions	Data	Analysis	Answer Questions
Achievement	Math Grades	Math GPA	ANOVA
Attitude	MDS	MDO	ANOVA

Definition of Terms

Attitude – a state of mind or feeling with regard to some matter; disposition

Peer tutor – one who is the same age who gives additional, special, or remedial instruction

Cross-age or cross-peer tutor – student of a different age who provides academic instruction

Limitations of the Study

Participants in the study were limited to students enrolled in the targeted courses taught this semester. There were 80 student tutors enrolled in Advanced Placement Calculus AB and Analysis. One-to-one pairings were desired, therefore dyads were

formed. This study was limited in scope since it focused on the central phenomenon that students are influenced by their peers. A further limitation of the study lied in the fact that the dyads decreased the ability to generalize the findings to other educational settings, hence this study will not generalize to all populations. An attempt was made to delimit the scope by focusing on the specific problem of students' difficulties in learning mathematical concepts and on particular participants in the study.

Inspiration for the Study

Teachers look to the National Council of Teachers of Mathematics (NCTM) to provide a common vision of the mathematical content which all students should learn in our nation's classrooms. In 1995, the NCTM set forth specific goals and performance standards aimed at shaping the teaching of mathematics through tasks, discourse, environment, and analysis. Performance based standards are aimed at students developing an appreciation for the beauty of mathematics, using logical reasoning, and solving non-routine problems. As educators, we strive for every child in our classroom to meet the standards put in place by the NCTM. Ideally, students should be encouraged by parents and teachers and supported by the administration in their educational endeavors.

The mathematics curriculum throughout the United States has undergone considerable revision in the last decade (Kilpatrick, 1997; Stigler, 1997; NCES, 1997; NCTM 1989, 1995; Raimi, 1998; U. S. Department of Education, 1999). Accountability and assessment standards are in place to determine whether there is proper adherence to the new curriculum. Mathematics is one of the subject areas selected for inclusion for the No Child Left Behind (NCLB) Adequate Yearly Progress (AYP) and greater emphasis is

being placed upon end-of-course tests as well as graduation tests, as a means of insuring that students are academically prepared for the work force. New developments within the mathematics curriculum, recent federal policies such as NCLB, and local issues regarding testing along with this researcher's personal experiences within the mathematics classroom prompted this study.

How is it possible for mathematics educators to achieve the goals set forth by the NCTM when public schools are charged with taking the bright, average, below-average, mentally challenged, physically handicapped, docile, indifferent, English speaking and English with Speakers of Other Languages (ESOL) students and encouraging all of them to reach their fullest potential? Alternative teaching strategies and assessments may be part of the solution; otherwise, some of our capable students will not succeed.

Research is a proven mechanism for professional educators to enhance their expertise and practices in the field of mathematics. Since the focus of this study was student learning, anticipated outcomes included establishment of peer tutoring programs and improved performance in mathematics achievement in other schools. The participants would become actively engaged in constructing their own mathematical knowledge base. Therefore, it was anticipated that much of the theory would emerge as the students' knowledge base was constructed during the tutoring interactions.

This research study could serve as an impetus for initiating tutorial programs as alternative teaching strategies or as additional measures to insure mathematical achievement. The results of this study may influence educators and students alike to seek the benefits of collaboration as an educational process. Peer tutoring has become an

established weekly routine at our school and motivated students are taking advantage of the opportunity. Teachers continually encourage more students that would benefit from the tutorials to attend the sessions and receive extra help in mathematics from their peers.

Summary

In the home and at school there are personal, physical and psychological challenges that students encounter in our changing society. Teachers, too, must deal with these problems along with disruptions and classroom management tasks. Although the teacher does well to address the overall needs of the class, it is not likely that this professional can adequately individualize instruction to accommodate all students within the allotted time period. Having students tutor their peers outside of class assists teachers. Peer tutors can help with comprehension of mathematical concepts or reinforce basic skills.

High school students influence their peers and this influence often has a mediating impact upon students' attitudes towards learning. The strength of this bond was examined within the African American community in which the study takes place. Furthermore, peer-influence coupled with academic assistance was investigated to identify peer tutoring as an intervention that will afford high school students higher achievement scores in mathematics.

Advanced Placement Calculus students are capable of solving many of the routine problems in mathematics that plague other students in courses which are prerequisite to the calculus. Therefore, it seems feasible that through training the calculus students can tutor their peers and help improve their peers' performance and their mathematical achievement. Pairing these two groups of students may have further positive implications

on a motivational and social level. Not only can mathematical performance be enhanced, but also attitudes regarding the learning of mathematics can be addressed as well with the implementation of this peer tutorial program.

The next chapter will provide a review of the literature pertaining to peer tutoring. Components which are relevant to the proposed intervention, namely peer and cultural influence, student achievement, student attitudes, and motivation towards learning will also be included in the discussion. In addition, a more in depth view of the theoretical underpinnings which provide the foundation for this research will follow.

CHAPTER 2

REVIEW OF THE LITERATURE

Extensive evidence exists within the current research literature that depicts peer tutoring as a mechanism for improving educational outcomes in a variety of contexts. (Topping, 2003, Early, 1998, Owens, 1993). Many studies have been conducted from elementary through post-secondary academe in which positive instructional outcomes resulted from peer tutoring. Research studies were not found that examined high school peer groups that involve African American calculus students and students in advanced mathematics courses which are prerequisite to the calculus. The current study will broaden the extent of the literature in this regard. Throughout this chapter lie the theoretical premises and empirical evidence found within the research lending support for the use of peer tutorials in this critical field of study.

Upon delineating the subject of this investigation, a systematic perusal of pertinent literature was conducted and analyzed. The review which follows is a discussion of the work completed by researchers regarding tutoring, achievement, attitudes, and peer influence. The majority of the research was purposefully confined to studies which were within the last decade. Theories pertaining to group learning before this period are also included in this discussion, because students will interact with one another in tutorial sessions. The manner in which children learn mathematics is an essential component of this research and some of these background studies provide the theoretical basis of education in our schools and are from earlier years.

Theoretical Studies

Lev Vygotsgy's socio-cultural theory contends that most learning occurs when students work collaboratively rather than independently. Vygotsky identified a Level of Independent Performance as the best a person could do alone and a Level of Assisted Performance as an individual's potential with the assistance of another individual. It is also theorized that there exists between these two levels, a Zone of Proximal Development (ZPD) which is the area where teachers should focus most of their attention because this area shifts upward as learning occurs (Vygotsky, 1962). Vygotsky spoke regarding school learning:

> Having found that the mental age of two children was, let us say, eight, we gave each of them harder problems than he could manage on his own and provided some slight assistance: the first step in a solution, a leading question, or some other form of help. We discovered that one child could, in cooperation, solve problems designed for twelve-year-olds. . . Experience has shown that the child with the larger zone of proximal development will do much better in school. This measure gives a more helpful clue than mental age does to the dynamics of intellectual progress. (p. 103)

Vygotsky read the work of Piaget and was influenced by him (Davidson Films, 1994) and like Piaget, Vygotsky created many of his own testing materials. Piaget's constructivist ideas could lend insight into how many subjects (or students) should be taught according to Kamii (Kamii & Ewing, 1996). Three reasons are presented for this claim: 1) Piaget's theory is scientific in nature in his explanation of human knowledge, 2) it is the only theory in existence that explains the construction of knowledge from birth through adolescence, and 3) his theory shows educators how Piaget distinguished three types of knowledge. These three kinds of knowledge are categorized as physical, social, and logico-mathematical.

Physical knowledge is the most common and easily acquired and refers to knowing facts such as colors and weights of objects. Social knowledge means conventional practices or social graces for instance which are acquired with age and practice, such as saying “excuse me”. Logico-mathematical knowledge involves spatial and temporal relationships formed by the individual. An example of this type of knowledge would be realizing that 1 + 2 = 3 is similar to the algebraic equation: $x + 2x = 3x$. This is a higher level of learning that requires the formation of abstract relationships. Since my study involved students in their early teenage years, Piaget’s study of children ages four through sixteen was particularly interesting and valuable in deciding the composition of the peer tutoring groups.

The distinction between procedural and conceptual knowledge (Hiebert & Lefevre) which are similar to Piaget’s classifications of physical and logico-mathematical knowledge is an important issue in today’s research. Psychologists and educators have recognized the relationship as significant to many learning processes and problems. Resolution of some learning deficiencies may occur with increased understanding of the acquisition of these types of knowledge and the interplay between them and the subject of mathematics. Over time the relationship between these types of knowledge is influenced by many forces and undergoes change. In the following experiment which was conducted by Piaget, it was demonstrated that construction of knowledge changes in the various stages of child development.

Piaget’s constructivism and his opposition to empiricism is demonstrated in his conservation of liquid experiments (Kamii & Ewing, 1996). The children based their judgment upon what they saw. They interpreted the empirical data and deduced that the

amount of liquid in the tubes was the same although one appeared to contain more. Children at various stages of development showed their construction of logic as they made drawings of their own impressions of U-shaped glass tubes containing water. Within a particular age group, according to Piaget, a child will draw the tubes in a manner consistent with other children in the same age group. This evidence supports the logico-mathematical theory that students form their own notions and interpretations based upon given information. To become further acquainted with Piaget's theory, and because fifteen-year-old students will be forming their own mathematical ideas, two children were tested. The conservation experiment was conducted using a ten-year-old and fifteen-year-old child. Their individual drawings were nearly identical to the sketches in Kamii's article. The results are shown in appendices D and E. Children are at a logical stage of development by the time they reach high school as supported by Piaget's study of conservation. Therefore, high school students are ready to construct their knowledge and can work with peers in accordance with Vygotsky's ZPD theory. It follows that teachers and tutors can help teenagers develop their understanding of basic concepts by utilizing Vygotskian socio-cultural learning theory. Similarly in this study, tutees constructed their own knowledge from the instruction provided by the tutor.

Ernst von Glasersfeld's constructivist views can be seen in his ontological stance. According to von Glasersfeld, constructivism is a theory of knowledge not of being (1998, p.41). This author asserts that there are two principles by which our construction of knowledge is guided. His first contention is that man is goal-oriented; we have likes and dislikes and our attitudes are formed as a result of these prejudices. Secondly,

Glasersfeld believes that our knowledge is constructed based upon our life experiences. In keeping with these principles, the goals, attitudes, experiences and cultural influence of the African American students as they develop mathematical concepts was of paramount importance in this tutoring study.

Jeremy Kilpatrick contends that it was not until the 1960's that renewed research interests surfaced as a result of Piaget's studies on growth and development of mathematical concepts. Kilpatrick also points out that until recently various social and cultural influences on thinking have often been ignored in scientific research studies (1992, p. 9). The effects that these influences have on instruction in our ever changing and more culturally diverse student populations cannot be ignored any longer. The study of the social characteristics of students as they pertain to mathematical acquisition of concepts should be a focal point of current research.

There are five strands which contribute to proficiency in mathematics according to Kilpatrick (2004). The strands are listed as: understanding, computing, applying, reasoning, and engaging. This investigation revealed a connection between peer tutoring and Kilpatrick's strands, a realization that may have resulted in increased mathematical proficiency for the African American high school subjects. The goal of the tutorials was centered around these strands: to increase understanding and improve computation, application, and reasoning skills. The study hoped to determine whether the attitudes of students would impact their decision to become engaged in mathematical discourse and participate in the activities. In this regard, the attitudes of peers and peer tutors play a major role in the learning process.

Empirical Studies on Achievement

Vygotsky's theory of cognitive development and the zone of proximal development is the basis for a peer tutoring study conducted by d'Arripe-Longueville (2002). Although the subject is physical education and not mathematics, the theory and procedures of d'Arripe-Longueville's study are closely related to this peer tutoring investigation. Specifically, tutees should experience gains in achievement when paired with a skilled tutor rather than a tutor who is a novice or one at an intermediate level.

D'Arripe-Longueville's study sought to examine how the skill level of a peer tutor affected the achievement motivation of novice learners and their swimming performance. Students were to train for eight minutes with a peer and the chosen task was the breaststroke turn. The participants were 48 French students, 24 males and 24 females selected after a pretest given to 306 twelfth-graders who attended three high schools in Paris. They were predominantly Caucasian and most were from working, middle-class backgrounds. Students volunteered for the study and their parents gave written consent. Swimmers were videotaped making two turns and evaluated on a four-point scale by judges who were unaware of the purpose of the study. Participants were assigned to six independent groups of a 2 x 3 design comprised of the following components: gender and tutor skill level which was classified as novice, intermediate, or skilled.

Results of repeated-measures analysis of variance, analysis of covariance, and multivariate analysis of variance indicated that all groups showed improvement in swimming skill from pretest to posttest. For the purposes of this study, it is noteworthy

that those paired with the skilled-tutor scored significantly better at posttest and retention test. As these results indicate, students perform better when paired with skilled peers rather than peers who are at an intermediate or novice skill level. Since pretest and posttest measures were taken in this study, the analysis conducted in d'Arripe-Longueville's study was particularly interesting and certain aspects of the statistical analysis were applicable to this investigation. Repeated measures analysis of variance was similarly analyzed and interpreted.

According to d'Arripe-Longueville, guidance techniques develop along with the skill level of the participants. Consequently, peers received more help through verbal information and demonstrations from their skilled peers than those who worked with less skilled peers. This is in keeping with the Vygotskian notion of learning through dialogue. The investigator suggested that future studies be conducted which promote more dialogue and multiple perspectives.

Learning through dialogue and demonstrations from a skilled peer as evidenced in d'Arripe-Longueville's investigation is a recommendation for using AP Calculus students as tutors. They are generally more skilled in mathematics than students who are in prerequisite courses. Transferring the principles of this physical education study over to the cognitive realm, it is conceivable that high school peers who are paired with AP Calculus tutors should perform better in mathematics than students tutored by peers in other courses. Students are expected to learn through scaffolding. Scaffolding is defined as: the building of new knowledge and concepts upon those already learned. Within this research, an awareness of the ZPD along with the student's previous experience in conjunction with scaffolding will help maximize student potential in the tutorial sessions.

Since the formation of dyads is critical for the proposed research, studies were sought which outlined methods that are feasible for this particular study. In one such study by Gabriele and Montecinos (2001), low-achieving students were paired with high-achieving students. The purpose of the study mentioned above was to examine whether learning or performance goals would influence the low-achieving students' perceptions of their high-achieving partners' competence in mathematics. The researchers also tested whether the participation and learning of the low-achievers would be impacted by these perceptions. Although the students in this study consisted of fourth and fifth-graders, the dyad formation was a good fit for this investigation.

Minority enrollment in the three schools participating in the Gabriele and Montecinos study was 15%, 18.9%, and 20.6%. These percentages were unlike the current peer tutoring study where minority participation was approximately 90%. From a pool of 332 students, Gabriele and Montecinos selected only those who met certain criteria for inclusion. The Iowa Test of Basic Skills (ITBS) and mathematics achievement scores from a previous semester were used to classify students as high- or low-achieving. If the ITBS was below the 40^{th} percentile, the student was given a low-achievement status and if the ITBS score was above the 80^{th} percentile, the student was classified as a high achiever. Students scoring between the 40^{th} and 80^{th} percentile ranks outside of these ranges, therefore they were excluded from the study.

Student selections were also made based upon the results of an initial pretest administered by the teacher to ensure that they had not already reached a ceiling on the mathematics problems that were to be administered during the sessions. The pretest contained three mathematics word problems. Low-achieving students were categorized as

those who missed all three questions. Students who answered at least two questions correctly were considered to be the high achievers. From the final pool of 141 students, a total of 70 students took part in the study.

The current study used a larger pool from which 138 students were chosen. Selection of participants underwent a series of steps to ensure the proper dyad formations which also narrowed the sample for manageability. Measures similar to those of Gabriele and Montecinos were employed for examining the achievement scores of participants in this research study. The tutees that were primarily low-achievers when compared to the calculus tutors, were the focus group of this investigation.

In the Gabriele and Montecinos study, data from the fourth and fifth-grade low-achieving partners was used in the analysis because the focus for the study was on low-achieving students. Separate two-way analyses of variance (ANOVA) were performed, focusing on gender and goal condition and also on grade level and goal condition as between-subjects factors. The results revealed no statistically significant main effects or interactions. Collapsing data and further analyses still showed no significant main effects for gender but indicated that the mean performance on the individual posttest was higher for low-achieving males than for low-achieving females. It was hypothesized that low-achievers would participate in a collaborative task differently with a high achiever when motivated by a learning goal than when motivated by a performance goal. The investigators expected low achievers who were motivated by learning goals to be more active participants in the collaborative process. Supposedly, they would contribute more ideas or questions in order to get feedback from their high-achieving partner than low achievers motivated by performance goals. On the contrary, low achievers who were

motivated by performance goals were expected to be more passive during collaborative problem solving and just go along with the thinking of their high achieving partner. Results indicated no differences in the amount or level of verbal exchange between partners given learning or performance goals. The hypothesis was not supported. Apparently, the students' interest in performance or learning did not influence their participation. Low achievers were not necessarily passive individuals in conversation with a peer as was also noted in this peer tutoring study. More research could be done on tutorial conversations.

In 1998, Janice Early conducted a mixed methods study on peer tutoring to investigate six hypotheses on the subject. One of Early's goals was to ascertain whether students' scores on the mandated proficiency tests in mathematics improved as a direct result of the tutorials. To determine this, she used three-stage stepwise multiple regression procedures in which various test scores were used as criterion variables. Levels of significance were set at 0.01 or 0.05 in this portion of her analysis. Another objective of the study was to learn whether the tutoring had an effect on self-concepts of the students involved. In this endeavor, Early employed the Student Self-Concept Scale (SSCS), academic self-concept scores, and SSCS composite scores.

The two-week tutoring sessions involved more than one hundred students divided into four sub-groups. There was an experimental group of sixty-seven tenth grade students who scored 84 or higher on the Texas Assessment of Academic Skills (TAAS). These students served as peer tutors. A second group comprised of 67 tenth grade at-risk students with low scores formed an experimental group that received peer tutoring. Another set of participants formed a control group of seventy-seven tenth graders who

scored at least 84 on the TAAS but did not participate in the tutorial sessions. The final group, also a control group, contained 78 at-risk tenth graders with low scores who were also excluded from the sessions.

Early concluded from her study that receiving peer tutoring was a predictor of academic achievement on the TAAS mathematics examination. She also determined that serving as a peer tutor in preparation for the examination had the effect of increasing the tutors' scores as well. Furthermore, it was revealed that participation in the peer tutorials yielded higher self-concept scores for both the tutor and the tutee. As a result of this intervention, tutors were able to assist the tutoring recipients in raising their mathematics scores and self-esteem.

Instead of the proficiency tests used by Early, the current study involved examination of students' mathematics grades before and after the tutorials. This was done to provide insight as to whether or not the tutorials had an impact on student achievement. A different instrument , the Mathematical Disposition Survey was employed to study the tutee's attitudes toward mathematics. Students in the current study are a year or two older than those in Early's research.

Another peer tutoring study involving middle school students explored the use of computer software by the music teacher. Forty children participated in the study, twenty tutors and twenty children who had fallen behind academically. Tutors were trained using a software program and within months, students' grade point averages rose. Tutors had to maintain a B average and referred to themselves as "peer pals". Use of a software program to train tutors for mathematics lacks feasibility and seems impersonal, however it appears useful in musical applications.

Arreaga-Mayer (1998) found class-wide peer tutoring (CWPT) to be a powerful intervention which promoted student involvement using a game format. The procedure resulted in increased mastery in mathematics, spelling, reading, vocabulary, science, and social studies. In this type of tutoring intervention, students interchange roles acting as both tutor and tutee. CWPT was also found to be particularly useful in increasing active learning and for students with disabilities. This type of tutoring intervention would be ideal for classrooms where students tend to be off task. Classroom management might be a challenge initially but certainly worth the effort. The many benefits of CWPT include early intervention, self-pacing and management, monitoring of student progress, direct teaching of academic and cognitive skills, and positive consequences for improvement. The CWPT system was developed by researchers in collaboration with classroom teachers specifically for children with learning disabilities or for children from minority or disadvantaged backgrounds. This intervention was particularly interesting because it was developed for the population of students within the current study. CWPT could prove to be advantageous in related studies.

In a similar study, Allsopp (1997) examined the effectiveness of class-wide peer tutoring for students at risk and those not at risk of failing mathematics. The participants in the study included 262 eighth grade students in 14 general mathematics classes from three middle schools in the southeastern United States. Students ranged in age from 12 to 15 years old. Four eighth-grade mathematics teachers volunteered to participate in the study, of which three were female. All of the teachers were certified to teach mathematics and had ten or more years of teaching experience. However, none of the teachers were previously trained in the algebra curriculum or in CWPT.

Research instrumentation included a pretest, posttest, and maintenance test to measure student problem-solving ability in Algebra. Also, a checklist, survey and Likert scale was used to assess teachers' and students' perceptions about CWPT. The procedure was divided into four phases. In phase one, there was an in-service for the teacher volunteers. Phase two consisted of student training in CWPT procedures. Phase three was the implementation of the treatment conditions and last was the posttest phase. All of these stages were employed in the current study with the exception of phase one. However, the in-service for the teachers is comparable to the training for the tutors.

Implementation resembled Allsopp's study in which two different treatment conditions were used. Students randomly assigned to both groups were instructed by the teachers for five consecutive weeks using an algebra program. One group practiced independently on worksheets after the teacher-directed lessons. The second group participated in CWPT to actively practice the skills after the lessons. The analysis involved repeated-measures analyses of variance which revealed no significant differences between treatment groups from pretest to posttest. Results indicated that students in both groups benefited from the instruction whether they practiced independently or interactively. Although CWPT was determined to be effective with basic academic skills, it was suggested that further research would be necessary to demonstrate the impact of CWPT on higher order thinking skills. Advanced mathematics may prove more difficult to manage through this tutorial process due to the higher order thinking involved. Swineford and Holtan (1991) conducted a study in which the primary focus was analysis of research findings on the teaching of mathematics. Their goal was to determine whether cooperative learning or traditional teaching methods yielded better

outcomes in student achievement and attitude. Data was collected on studies dating from 1970 involving students in kindergarten through grade 12. The educational data sources used included Educational Resources Information Center (ERIC), Dissertation Abstracts International (DAI), and the Journal for Research in Mathematics Education (JRME). Forty studies on student achievement and 25 studies on student attitudes toward mathematics were involved in the final analysis. The researchers used the method of meta-analysis to synthesize findings and the significance of effects of the various interventions. Swineford and Holtan's conclusions revealed peer tutoring as the best method of instruction for increased achievement which supports the rationale of the current study. Team Assisted Individualization (TAI) was found to be the best method for change in attitude to occur. Since attitudinal changes were not pronounced at the conclusion of this study, incorporating ideas from TAI is encouraged.

A university in the southeastern United States participated in an investigation of the relationship between peer tutoring and achievement versus academic locus of control, self-efficacy, mathematics anxiety, and motivation (Owens, 1993). Results of various quantitative measures revealed no significant relationships between dependent and independent variables in the study. However, high school grade point averages had a strong mediating influence on the results with regard to gender, point of entry, and grades earned in college Algebra. Owens determined that gender related significantly to mathematical anxiety, which was an expected outcome of his study. He also found that point of entry was linked to achievement, as was persistence with peer tutoring. The participants in Owens' study were college freshmen. As a result of Owens' study, gender

issues were examined closely as they relate to math anxiety. Gender considerations were taken into consideration in the dyad formations for the current study.

Students may achieve similar results whether tutored by teachers or peers as evidenced in a Maryland study conducted by Kaylor & Wilson (1985). In this study involving ninth grade remedial mathematics programs, Kaylor and Wilson compared four instructional interventions for students who failed the Maryland Functional Mathematics Test (MFMT): 1) In-Class Remedial, 2) Individual Teacher Tutoring, 3) Individual Peer Tutoring, and 4) Whole Group Remedial. The null hypothesis that the effectiveness of the various methods would yield no significant differences was upheld. Participants who were tutored by their peers in the Honor Society had scores equivalent to those who were tutored by teachers. This outcome lends support to idea that peer tutors can assist teachers and obtain outstanding results in the process.

Attitudinal Studies

Any research project which includes predominantly African Americans in an educational setting should address the issue of motivation in the students, since motivational issues hinder their academic potential (Vaughan, 2002, Graham, 1994). One of the most definitive studies was completed in 1994 by Graham entitled *Motivation in African Americans* and includes many factors which affect the learning for this group of students. While much of the research dates back to the fifties and sixties, the author does update the data and establish a more modern attitude towards the school climate witnessed today. A key factor used to examine the attitudes of African American students educational outlook was the how the culture was affected by its close association with the

low socioeconomic status (SES) of the group as a whole. As the group used in this research is derived from a predominantly middle class neighborhood and all the students in these mathematics classes are on a college bound track, some inferences may be made. However, these academic attitudes should be minimal in the overall group and should have little effect upon the results obtained.

As a preface to the discussion of Graham's research, it should be noted that a main postulate of the author is that "Black subjects maintain undaunted optimism and positive self-regard even in the face of achievement failure" (p.103). This factor may tend to alleviate much of the anxiety associated with mathematics related tasks in a peer related activity. One can surmise from this belief that motivation and the associated effort put forth by African American students would not be adversely influenced by the initial lack of success in the mathematical peer tutoring model suggested by this research. As the subject of mathematics has little to do with societal values, even less correlation to motivational constructs of the Graham research can be observed.

The most significant aspect of Graham's research may be derived from the *Principles of Motivational Psychology for African Americans* which the author includes in her discussion section of the article. Six concerns of the author in relation to the topic are addressed and were taken into consideration in this research. The first involves the self-esteem of the African American learner. The tradition of low self-esteem associated with black children has been done away with through empirical evidence, and goal-directed behavior has become predominant with this group. Graham believes that none of the variations in the concepts associated with self perception can be attributed to race.

The next area discussed is the cognitive variables, such as causal attributions, perceptions of control and expectancy for success on the part of the African American student. According to theories presented, "the more stable the cause for success or failure, the higher the expectation that the same outcome will be repeated" (p. 105). This basic cause-effect relationship in education would be minimized by the use of mathematical constructs which are inherently devoid of cultural attachments. The value of attaining academic achievement was seen as a positive consequence and easily identifiable with mathematical evaluations. Graham states that "the study of achievement values as they get expressed in the broader context of parent, teacher, and peer influences may prove to be a key construct in the motivational psychology for African Americans" (p.106). The component of peer interaction in the current study provided a motivational boost to student achievement.

Thirdly, the author addresses the dynamics of failure on the part of the African American student. While this group is overrepresented in economically disadvantaged black children, the current research project does not reflect a preponderance of these individuals which might skew the overall results obtained. Chronic achievement failure by members of the group studied is not a main characteristic and effects should be insignificant. However, this researcher will "be particularly sensitive to how individuals think, feel and act in response to non-attainment of goals." (p. 106). This was addressed with aspects of the study where academic success was not attained by individual students.

The fourth concept espoused by Graham is the complex relations between race and social class in our society. The effects on the current research project were nonexistent

as the entire sample consisted primarily of African American students from similar economic situations. Any future research in this area may be directed towards other strata of SES within the African American community which may include variables not delineated in the present study.

Similarly, Graham's next concept deals with the varied socialization (childrearing) antecedents of achievement strivings. These are the main parent practices in relation to their child's academic behaviors and achievement levels as assessed by their schools. Main parts of this concept include homework completion and scrutiny of day to day progress in school. As this peer tutoring study dealt mainly with in school tutoring and teacher monitoring of student progress, the impact of this component is minimal in relation to the results obtained.

The last aspect of motivational psychology for African Americans is that it should be able to contribute to the general principles of all human behavior. Graham suggests that her intensive research on motivation should inform and benefit mainstream psychology. Three of the main characteristics identified in the African American educational approach were seen as basic adaptive strategies for mental health and well being. These included high expectancies, unusually positive self regard, and exaggerated perceptions of control. These indications were first identified in the early 1970's but were disregarded due to an overemphasis on the black-white debate in educational academia. The lesson to be learned here is that research, including this current study should be seen in a broader scope with possible applications for any segment of the student population.

A study by Young (1992) analyzed essays written by 47 teacher education students in response to the question "If you could live your high school days over again what, if

anything would you change?" The responses strongly suggest that for many high school students, their general attitude toward school affects achievement more that do attitudes toward specific school characteristics. The study revealed that despite the wealth of criticism of American education, too little attention was given to what students think about their roles in high school.

According to Young, professionals as well as parents have long known that many students do not take the academic side of school seriously. No amount of "fixing" the schools will be effective for these students unless it takes into account their attitudes toward school and themselves. However, there is widespread agreement among educators that students' attitudes toward school greatly influence their performance. The many national reports on education during the 1980's paid scant attention to this critical factor. Instead the reports tended to dwell on specific elements of the school, presupposing that improvement of these elements would result in improved student performance.

Young's study affirms that an examination of educational journals since 1984 revealed a lack of attention to high school students' global or holistic attitudes towards school. There have been many studies about attitudes toward individual aspects of school, for example, mathematics, computers, the handicapped, alcohol, and drugs. However, the investigators found none that examined students' general attitudes toward themselves and their school experiences. A few studies examined specific aspects of the students' school relationships that are relevant to the present research. Bishop (1989) examined the issue of apathy in American high schools and concluded that it is a major problem. Goodlad (1984) and Sizer (1984) also described passive, docile, and apathetic behavior among high school students.

Gendara (2001) examined how students from different ethic groups form their expectations about school. She goes further to focus on how peers and families shape students' attitudes and aspirations. The study followed the class of 2001 from the beginning of high school in 1997 until graduation in 2001. Participants included 473 African American, Latino, Asian and European American adolescents. There were 297 students remaining from these groups in 1997 most of whom were Latino. Qualitative and quantitative data was collected that included ethnography, observation, and survey data. The research team was comprised of a very diverse group of faculty, graduate students, undergraduates and high school students.

Although literature shows that peer influence peaks around age 14, Gendara's study found that the influence of close friends in cliques may diminish over time along with peer pressure to engage in risky behaviors, however peer pressure continues in a different form. Peers that represent the kind of person students aspire to be may exert considerable pressure on students. The researcher disputes the claim of African American students harboring fears of "acting white." Her research suggests that they have high aspirations for school achievement and do not resist being a good student. Gendara further suggests that ethnographic and interview data yield more accurate information on African American students than surveys. It was taken into consideration for the current study that any population of students would more likely be disingenuous in their responses to surveys rather than interviews. Inhibitions due to parenting practices or peer groups influences cause reluctance in responding openly and honestly for some adolescents. This tendency was not discounted in the present study, and the survey was thoughtfully and purposefully selected for inclusion.

Due to the importance of parenting influences, one objective of a recent study conducted in the United Kingdom, included the involvement of every class in some form of peer or parent paired learning in developing mental mathematics skills. The researchers (Topping, et al, 2003) sought to determine whether a structured cross-age peer tutoring program using mathematical games with seven and eleven-year-old students would positively impact their attitudes towards the subject of mathematics. The study was also concerned with investigating the impact on the skills, knowledge, social and emotional factors that affected the tutors or tutees. A primary objective of the researchers was to develop the skills and confidence relevant to transferring to the high school.

The project took place in a small rural primary school in Scotland that adhered to the nationally prescribed curriculum in mathematics. The mathematical games used included Labyrinth, Yahtzee, and Uno which were also used in a previous study (Topping & Bamford, 1991). The intervention lasted five weeks, with two sessions of 30 minutes each week in which students played these games. Verbal interaction was recorded for a sample of pairs of students during pre- and post-intervention. Tutors participated in feedback discussions at mid- and post-intervention and teachers gave post hoc subjective evaluations of their observations.

Verbal interactions were not recorded in this study, however future studies should be conducted on the importance of such exchanges. For Toppings' project these interactions showed significant increases in the use of mathematical words and strategic dialogue. Other qualitative improvements in peer interactions were evident. There was more praise between partners and a decline in procedural talk. Upon conclusion of the study, the researchers found that the tutors showed significant gains on the MALS(Me-As-Learner

Scale) and the BIOS (Behavioral Indicators of Self-esteem Scale). Tutees' gains were also significant on the BIOS measurement.

Questionnaires directed at feelings and attitudes towards mathematics did not show increases in tutors but in tutees. Apparently, academic success offered the tutees a sense of increased confidence in their skills and improved their positive outlook on the subject. The project appeared largely successful in increasing the self-esteem of tutors and tutees. This tutoring study used peers as tutors, but unlike the study by Topping, participants were of high school age and the intervention lasted longer than five weeks.

The effects of collaborative peer tutoring on students' self-concepts and attitudes towards school were investigated in a study by Roswal, et al, 1995. There were 282 seventh grade subjects that participated in the study. The research site was a large urban junior high school. Many of the participants had been previously identified as at-risk students by traditional means of identification. Approximately half of the subjects in the present study participate in school programs designed for at-risk students.

The junior high school students were assigned to one of three heterogeneous groups. One group consisted of 101 students who participated in a class using a peer tutoring teaching program. Another group contained 95 students in a traditional class with group learning activities. The final group of 86 boys and girls were in a traditional class based on individual learning activities. All of the groups were similar with regards to language and ethnicity. English was the primary language for 97% of the participants and 80% of the students were African American. Hispanics and Caucasians made up 17% of the population and some students of other races participated in the study.

The Piers-Harris Self-Concept Scale (Piers & Harris, 1969) was an instrument used in Roswal's study to measure the self-concept of the subjects. Additionally, the Demos D (Dropout) Scale was used to measure the students' tendency for dropping out of school. An alternative method for ascertaining students' attitude towards school was to compare attendance for the four weeks prior to the intervention with attendance for the final four weeks of the program. Data was collected at the onset of the 16- week tutoring program and at its completion.

A post-hoc analysis showed evidence that drop out scores and self-concept ratings improved as a result of the collaborative tutoring program. The researchers found that students' self concepts improved as they began to understand that the success of the team was dependent upon each team member. Teacher anecdotal information revealed that this was true for high achievers and low achievers. There was no significant difference observed for the non-tutored classes of students using group or individual learning activities. Scores remained relatively stable for those students who were in the traditional classes that received no tutoring.

The objective data which was collected in this study was supported by anecdotal data collected by the teachers. This data further showed that the students who participated in the collaborative peer tutoring enjoyed working on academic teams, frequently submitted homework, exhibited tolerance, and were motivated to attend school. Using only quantitative measures would have neglected some of this informative data. Using a mixed methods approach incorporates various artifacts to render a comprehensive result.

Popular games were used in an earlier study by Topping and Bamford (1991) in which feedback was gathered from Scottish students of the same age to examine the

effects of the intervention on participants' attitudes, self-esteem, and performance on a mathematics test. The school involved in the project had a mixed population and many of the students were from single parent homes and some were socially deprived. The experimental group was comprised of 25 ten-year-olds and the comparison group was made up of 20 children who received normal classroom instruction but did not play games. Among the games favored most were, Labyrinth, Yahtzee, and Uno which are not overly complicated and offer success to most players. The students were placed in pairs and played games during two 30-minute sessions twice each week for six weeks. Participants liked the games and said they felt most of the games were interesting and made them think harder. It is interesting to note however, that they were unsure if they liked mathematics any better as a result of the games as the amount of mathematics needed to play the games was minor.

Results showed no changes in participants' attitudes toward the subject of mathematics as revealed by pre- and post-test scores. Upon conclusion of the study, self-esteem was significantly higher for the experimental group and lower for the comparison group. Post test results showed increases in raw scores on the mathematical test for both groups of students. Some aspects of the current study resembled Topping's approach, since there was a control group and an experimental group of students and their attitudes toward mathematics was of interest; however, games were not used in this research investigation. Instead, this intervention involved working with a peer tutor.

Fifty-eight university freshmen participated in a quantitative attitudinal study by McKethan (1982). The study was designed for a comparison of students' attitudes towards mathematics and achievement in mathematics. Twenty-five students volunteered

to be included in the treatment. Twenty-eight students who did not wish to participate were assigned to the control group. Five students were involved in a two-week peer tutor training session. The experimental group received structured peer tutoring in mathematics for 55 minutes biweekly for 12 weeks and the control group received no tutoring.

Pre- and posttest measures were administered to both groups. These measurements included a computation test, semantic differential attitude scale, and a self-assessment instrument developed by the researcher. Two hypotheses were tested at the .05 level of confidence: 1) There is no significant difference at the end of 12 weeks of treatment in attitude toward mathematics between students who received structured peer tutoring and students who received no tutoring, and 2) there is no significant difference in achievement in mathematics between these groups.

The first hypothesis was accepted due to the results obtained from the study. All of the participants had a positive attitude toward mathematics; however, subjects in the experimental group showed a significantly higher mean score on the attitude scale than the control group. Findings indicated little to no change in mathematics achievement for the control group or the experimental group, the second hypothesis was thereby rejected.

McKethan's study was quantitative and involved remedial mathematics. The current study also employed quantitative measures but studied students in on-level and advanced mathematics classes. Implementation procedures and methods of analysis are similar to McKethan's in that pre- and posttest measures were used and tutors were trained for a period of time. The hypotheses which McKethan tested are comparable to the questions of the current study. For a clearer understanding of the tutorial relationship, the interaction among the peers were examined using surveys and methods adapted from the

following study in an attempt to capture the students' feelings about mathematics and their peer tutor.

Donovan and Beveridge (2004) developed a survey to examine students' disposition towards mathematics. Their instrument was adapted from the Maryland Physics Expectation Survey (MPEX). In working to develop this survey which is shown in Appendix 2, Donovan and Beveridge conducted a pilot study in which 585 respondents provided pre- and post test data. The MDS was administered to 17 classes on the first day of class and during the last two weeks of class.

The researchers developed authentic means of evaluating the data which they named the Mean Distance from Optimal (MDO). Responses were viewed numerically from 1 to 5. Experts had agreed upon favorable or optimal responses which they indicated with the number 1 and 5 for items with which the experts disagreed. Taking the weighted average of the mean agree distance and the mean disagree distance yielded the MDO result. For each class, the pre and post test mean MDO was compared using the paired t-test. This process was modified to fit this particular investigation. Another instrument used by Donovan and Beveridge was an open-ended response item (shown in Appendix C). Participants were asked to give one word to describe their feelings about mathematics. The results were compiled in a table displaying among other things the frequency, mean, median, and range. This instrument was also considered for use in the current study.

According to Valeski and Stipek (2001), the attitudes of students towards learning contribute to their success in school. Data was collected from 225 kindergarteners and 127 first graders using a new measure, Feelings about School (FAS). The instrument measures children's perceptions of academic competence, feelings about the teacher and

general attitudes about school. A similar instrument was employed to examine the attitudes of participants in the current study. Modification of the FAS instrument would permit its use with the tutees in a high school setting, however the survey that was used by Donovan and Beveridge was preferable because like this peer tutoring study, it was specific to the subject of mathematics.

The self-systems theory of engagement served as a guide for Valeski and Stipek's study. According to this theory, within an academic learning environment, children possess three psychological needs which need to be met in order for maximum benefits to occur: 1) to feel academically competent, 2) to feel socially valued, and 3) to have a sense of autonomy. Although peer tutoring did not occur and participants in their study were elementary school age children, the theory, procedures, and findings are relevant to the current study. Results of this attitudinal study support the contention that children who enjoy school and have confidence in their ability to succeed in school will be more likely to become engaged in learning activities than students who have negative attitudes about school. High school students want to feel as though they are socially connected, and working with trained peer tutors should help in fulfilling this need. As with Valeski and Stipek's study, an expected outcome of this investigation was improved performance as tutees' attitudes towards their learning improved.

While a change in attitude may result in improved achievement, there are other variables involved, as evidenced in a recent TIMSS study . A study by Schreiber (2002) surveyed advanced mathematics students from sixty-two schools. Information was collected from TIMSS indicating the factors which influence achievement are gender, attitude, economics, school size, and parent education. This study emphasizes the

aspect of attitude as a prime contributing factor to success in the mathematical achievement of African American high school students.

Since 1995, minority students in the United States made impressive gains in eighth-grade mathematics scores (NCTM, 2005). The average mathematics scores of African American eighth grade students increased by 29 points. Hispanic scores increased by 22 points. The achievement gap among black, Hispanic, and white students has also narrowed significantly. There was previously a 97-point difference between the average mathematics scores of black and white eighth graders along with a difference of 75 points for Hispanic and white students. Latest TIMSS results shows a 77-point difference in the mathematics scores of black and white students and a difference of 60 points between Hispanic and white students. The results highlight a need for policymakers to provide an equitable education for all students. Implementation of systemic tutorial programs could be a step in the right direction toward closing the achievement gap among African American, Caucasian, and Hispanic students.

Since the early seventies, many research studies have been conducted on the premise that peer tutoring could serve as an intervention for students who are at-risk, have limited English proficiency (LEP) or who are identified as having learning disabilities (LD) (White, 2000; Hindley, 2003; Lee, 2000). Barfield's 1998 study was particularly informative with regard to the implementation of a peer tutoring program.

Barfield's study dealt with students with disabilities who were integrated into regular physical education classrooms and his methods were useful for this research. The study outlines the benefits, goals, and objectives of a peer tutoring program. The researcher elaborates on means of evaluating student performance and the formation of dyads by

matching peers across personal interests as well as ability levels. Special attention is given to the training of tutors in this particular study because they were sometimes working with peers who suffered extreme disabilities. Barfield's training strategies served to adequately prepare the tutors in the current study. While this study does not examine students with disabilities or LEP, it was determined that many of the tutees were classified as students at-risk and that these limitations could influence some of the results achieved from the investigation.

A foreign language tutoring study was conducted by Matthews (2001). Two hundred sixty-two university students who had never sought tutoring were studied along with 29 students seeking one-on-one tutoring. The participants were assessed for performance goal and mastery goal orientations toward achievement and self-efficacy for learning foreign language.

Upon comparing four sessions with the most marked gains in self-efficacy with four sessions with the most marked decreases, various characteristics of motivationally effective and ineffective tutoring sessions were noted. These differences included structural characteristics such as session length, overlapped speech, and lack of tutor knowledge. Successful sessions were found to be shorter with less overlapped speech. Discourse in successful tutorial sessions were characterized by focusing on the rules of foreign language and detailed explanations rather than superficial correction of the tutees' work. Analyses revealed that the tutees had lower overall grade point averages but higher mastery and performance goal orientations than other classroom students. A significant mean improvement was shown for tutee's pre- to post-tutoring self-efficacy for foreign language learning. Detailed explanations during tutorials will aid students

in mathematics also, instead of merely correcting a tutee's errors. This foreign language study further highlights the significance of dialogue between tutor and tutee.

Fantuzzo and Rohrbeck (1992) examined the effects of peer tutoring from a self-management perspective. This idea coincides with the problem of teacher time allotted for students requiring assistance discussed in the first chapter. Teachers should use peer tutoring in such a way that it maximizes classroom resources. Students can work cooperatively while the teacher is available to be more attentive to individual differences.

A self-management approach to learning inside the classroom is not within the scope of the current study. Yet, if peers can learn to help one another outside of class this could carry over into lifelong learning. In Fantuzzo and Rohrbeck's study, reciprocal peer tutoring was implemented in an urban public elementary school, but can be shown to hold promise on various educational levels. Peer tutoring is a strategy with self-management features for use in any classroom.

Peer tutoring was found to be an effective educational strategy for diverse learners because it promotes academic gains as well as social enhancement. Implementation of programs can occur at the classroom level, school-wide, or district level tutoring programs can be initiated. Fantuzzo and Rohrbeck concluded that peer tutoring can help teachers cope with limited instructional time as students engage in active learning in which they are accountable for their achievement and have control over their progress. Three examples of structured peer tutoring were investigated to determine how they promote access to the general education curriculum and evaluate the effectiveness of the programs. These examples included: Peer-assisted learning (PALS), Cross-age tutoring and Reciprocal Peer Tutoring (RPT). The investigators worked with a definition of peer

tutoring as an instructional strategy consisting of student partnerships linking high achieving students with lower achieving students for the purpose of structured reading and mathematics study sessions. Fantuzzo and Rohrbeck's comparison of these tutoring approaches is shown in the following table.

Table 2

Comparison of Approaches

Approach:	Cross-Age Tutoring	PALS	RPT
Content Area*	Multiple content areas	Math & Reading*	Multiple content areas
# of Students	2	2	2 or more
Role of Student	Tutor or Tutee	Tutor & Tutee	Tutor & Tutee
Type of Interaction	Expert/Cooperative	Cooperative/Competitive	Cooperative
Type of Reward	Social Reinforcement	Social Reinforcement & Earn Points	Social Reinforcement Earn Points

Note. Research exists in these content areas. Approach may be used in other areas.

The students expressed their attitudes toward RPT in questionnaires. Approximately 85% felt that the process would benefit them in their other classes. About one third of the participants felt that the peer tutoring component was less helpful than writing the questions. Some considered the tutoring to be confusing and detrimental. No explanation was given for this claim; however, it could be that the tutors were not proficient in

reading or mathematics. Also, it appears that no training of the tutors occurred in this study. It is interesting to note that one student commented that the RPT process helped relieve his test anxiety by allowing him to relax. He said it was like a basketball player practicing free throws before the game.

Empirical studies within this search of the literature have shown that peer tutoring impacts both the achievement and attitude of the tutees. Results of these investigations included academic gains, increased self esteem, improved attitudes, and reduced anxiety. Studies also revealed the type of criteria necessary for peer tutorials to be effective. The tutors should be trained and must know the subject matter. Tutors with weak content knowledge will not be much help to others who are also weak. Since the calculus students, who are high-achievers will be paired with low-achieving students, there is no anticipation of undesirable results due to lack of content knowledge within tutors. Research supporting the use of peer tutoring to help minorities learn mathematics is sparse. This study contributes to the field by promoting peer tutoring as a means of engaging all groups of students and making advanced mathematics courses more diverse.

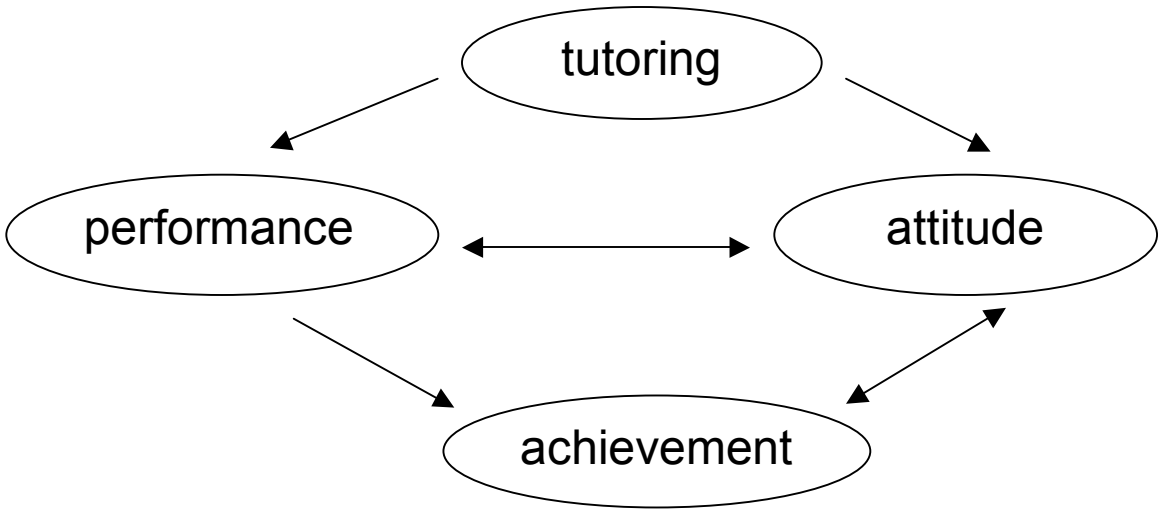
Hypotheses

Reviewing the pertinent literature helped to strengthen the focus of this research investigation. Knowing what had been explored in mathematics education in recent years served as a guide toward selecting a study that would make a contribution to the field. Previous studies also gave tremendous insight into how a similar study should be designed. This design will be discussed in detail in the next chapter. The following hypotheses were investigated in this study:

1. There is a significant difference in the mathematical achievement of students participating in peer tutorials and students who are not being tutored.
2. Tutoring by an individual's peer will have a significant impact on their attitude towards engaging in mathematical learning activities.

Although the impact of the intervention on tutors is not a primary concern, it is necessary to be aware of the potential influence of the tutors. Beliefs impact attitudes and attitudes affect performance; subsequently, performance and attitudes affect achievement. Research studies have been shown to link tutoring with achievement, performance, and attitudes (Topping, 1998; Stipek, 2001). The concept map is an attempt to display the relationship concisely.

Figure 2. Relationships among various tutoring outcomes (Hannah, 2008).



Tutoring may directly affect performance and performance, subsequently impact achievement. In another possible path, tutoring may affect attitudes, then achievement via attitudinal changes. There is a bi-directional influence that relates performance and attitude and also between achievement and attitude. For an overview of the framework, see Appendix A.

Developing a peer tutorial program has implications for increased success in learning mathematics in our educational systems (Topping et al, 2003). Conceptually, this goal can be achieved through tutoring as it has been shown to improve performance, achievement, and attitudes towards learning in general (Cohen et al, 1986). The pathways of these related components are applicable to any academic endeavor and not only mathematics education. Every dedicated educator must desire and seek ways for students to learn more effectively through experimentation and hard work.

Summary

Not much has surfaced in the last decade concerning the impact of tutoring on performance and attitudes toward high school mathematics. The current study is the first to examine the interactions of African American students in Algebra and Geometry as they are tutored by Advanced Placement Calculus students. Evidence gathered through careful analysis of data collected from school records, tests and surveys was used to determine whether the tutoring sessions had an influence on students' attitudes or an impact on their achievement in mathematics. It is a reasonable expectation that over time

the mathematical attitudes of students will change for the better as their performance in mathematics courses improves.

Bright, successful, and perhaps more popular peers from higher level courses such as AP Calculus are likely to have a positive influence on the attitudes and beliefs of students in prerequisite courses that are not performing well. Participation in peer tutorials as a tutor or as a recipient of tutoring has led to improved self-concept scores. Given proper pairings of trained tutors with willing tutees, the outcome of the tutorials should be increased self-concept, better performance, and higher achievement scores (Topping, 2003, Early, 1998, Owens, 1993).

The current literature provides evidence that depicts peer tutoring as a means of improving educational outcomes in a variety of contexts. Studies with positive outcomes have been conducted on various educational levels in many fields of study including physical education (d'Arripe-Longueville et al, 2002) and foreign language (Matthews, 2001). This research study expands the current literature through examining the interactions of teenagers engaged in peer tutorials. As these teenagers studied mathematics together with their peers, this investigation sought to identify peer tutoring as a viable strategy toward changing negative attitudes towards mathematical instruction. It is also possible that peer tutoring will increase the capacity for all students to improve their mathematical comprehension.

Initiating peer tutoring programs which use AP students as tutors should help to close the achievement gap of minority groups and enable all students of mathematics to reach their fullest potential. In the process of implementing such programs, the equity goal of the National Council of Teachers of Mathematics (NCTM) will be fulfilled to some

degree and “Mathematics can and will be learned by all students”(NCTM, 2000, p. 13). After all, as educators it is our goal to study instructional methods that increase learning in our schools and to make sure that the term ‘No Child Left Behind’ is not merely a slogan, but a reality.

CHAPTER 3

DESIGN OF THE STUDY

A researcher does not arrive at the design of a study through selection. The research questions dictate the design. To best answer these questions and determine the significance of the tutoring intervention, statistical measures of collecting pre and post-intervention data was used throughout this investigation. As defined by Creswell (2003), a quantitative approach is one in which the investigator thinks of cause and effect and plans to use measurements and observations to test theories.

Quantitative methods which are best suited for measuring variance were employed for this student population. A quasi-experimental design (Creswell, p. 169) was used to test whether or not peer tutorials cause a change in mathematical attitudes. The subjects were not randomly assigned. Two groups, a control group and an experimental group, completed pre- and post-intervention surveys but only the experimental group received treatment. The specific group of people that are the foci in the study are high school students enrolled in AP Calculus and prerequisite mathematics courses. Choosing this focus separates a group of students from a community which is ordinarily integrated (Bogdan & Biklin, 2003). Students may not behave in smaller groups as they would in a normal classroom setting.

Setting

The high school studied was established in 1892. It is a new facility in a new location which is centrally located in a suburb of a large metropolis in the southeastern United States. Surrounding the school are newly built upscale subdivisions, older smaller homes, and a few businesses. Subdivisions of homes valued at a half-million dollars lie west of the school. To the east, are older homes and farther east are low-income housing developments and a municipality. North and west of the school there is a national park that is frequented by hikers and visitors. A growing rural community lies further west.

The faculty is approximately 40% African American, 55% Caucasian, and less than five percent other ethnic groups which includes Hispanic and Indian descent. The student body is 46% African American, 38% Caucasian, 12% Hispanic, and 4% belong to other ethnic groups. The socioeconomic status of the student population is varied, composed of a mixture of upper middle class, suburban, and inner city youths.

The building is only five years old and is a beautiful facility with a fully-automated media center, science labs, seminar meeting rooms, 10 lighted tennis courts, and a gymnasium with an indoor track that seats 3000. Classroom wings are enormous, well equipped and very well maintained. Funds are readily available for teacher supplies because the administration is extremely supportive and the school houses an international baccalaureate program. However, teacher turnover is increasing with one third of the mathematics department replaced by new teachers this year.

Students who are in the international baccalaureate program tend to be gifted in particular subject areas and truly motivated. Students must maintain above a 3.0 average

to remain in the program. Overall the atmosphere suggests a sense of comradery among faculty members. Teachers feel valued as they are allotted time to adequately plan lessons with others in their department.

My Role as the Researcher

It is undeniable that personal values, experiences, and biases will influence research. No matter how I try, I cannot divorce my research or my writing from past and present experiences (Bogdan & Biklen, p. 34). Although my beliefs undoubtedly influenced this study, my aim was to remain open minded in permitting the data to inform my thinking. Furthermore, through a thorough understanding of the setting and participants, I attempted to extract any effects that my presence may have caused in this investigation. I strived to maintain a balance between participant and observer.

For the last 10 years I have taught Calculus, Pre-Calculus, Algebra Two, and Honors Geometry. Currently, I am teaching Algebra and Geometry in a new school district close to home. I am now concentrating on my teaching duties, graduate school assignments and tutoring twice a week. My schedule has also kept me engrossed in this research project in hopes of improving mathematical education in my own school as well as many others. Finally in describing my role as the researcher, I am the teacher, primary data collector, and tutor trainer, but not an active participant in the peer tutorial sessions. The students interact with one another without my direct supervision.

Participants

One hundred thirty-eight freshmen, sophomores, juniors, and seniors from a public high school in the southeastern United States participated in this study. They were

selected from the Math Honor Society and 90 students enrolled in the researcher's three mathematics classes, including two Algebra classes and one Geometry class. The Mathematics Honor Society has approximately 80 students engaged as peer tutors. They are enrolled in Advanced Placement Calculus, and Analysis. These individuals receive community service hours for the time that they devote to peer tutoring. The majority of the students are in calculus and form a close group that have remained in classes together for three or more years. Only students performing on a high level were chosen as tutors. The Geometry and Algebra classes were polled to determine what students were interested in attending tutorials and lists generated.

There was an informal get-acquainted session after school for the tutors and tutees to meet one another. Another list was compiled of prospective pairings. The list was perused to determine whether it was feasible for the two students to work together based upon the teacher's insight into their personalities and work ethics. After dyads were set up, the tutors were identified and training sessions began.

The student tutors enrolled in AP Calculus received on site training for one week using methods outlined by Goodlad and Hirst (1989) and Rabow, Chin, and Fahimian (1999). Tutorials were held one hour each week for a period of six weeks. The participants agreed to meet on Thursdays from 3:00 until 4:00 p.m. after school in the teacher's classroom. In an effort to accommodate all participants, other nearby classrooms were also used for the students and peer tutors to work. Every attempt was made for the sessions to be convenient for the participants and manageable within their schedules. Many of the subjects were involved in extracurricular activities in school and within the

community. Because of this, it was important for the tutoring process to remain flexible in order for it to be successful for these students.

Instruments and Measures

The Mathematics Disposition Survey (MDS) (Donovan & Beveridge, 2004) was designed to study students' attitudes using a five-point Likert scale. The MDS was administered before and after the tutoring intervention in order to measure the tutees' attitudes towards mathematics. Subjects' attitudes were evaluated using their responses to the 31-item survey. Of the 31 statements, 11 are considered agree items or positive and 20 are disagree or negative statements. "Understanding mathematics basically means being able to recall something you've read or been shown." The preceding statement is an example of a negative item because most mathematicians would not agree with this statement. However, "I use the mistakes I make in solving mathematics problems as clues to what I need to do to understand the material better," is an instructional concept that mathematicians share and this would be considered a positive statement. The survey contains 11 agree items (3, 4, 7, 10, 16, 23, 24, 25, 29, 30, 31) and 20 disagree items (1, 2, 5, 6, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 26, 27, 28).

Final course grades in Algebra and Geometry were compared to grades earned earlier In the semester. The grades in these same courses were initially recorded, prior to the tutoring intervention as a measurement of mathematical achievement. The students' transcript or teacher's grade book was used to view the students' grades which provided a foundation for the dyad selection process.

Reliability

The original Maryland Physics Expectations (MPEX) Survey was tested for reliability and validity. Validity was demonstrated by studying the results of calibration groups and more than 120 hours of student interviews. Procedures were in place throughout the investigation to ensure reliability of measurement and instruction. Peer tutors and students receiving tutoring were observed by this researcher during tutorial sessions. Their interactions were noted and if necessary suggestions were made to the tutor by the teacher. This teacher used a subtle approach so that the tutors' ability was not in question nor their authority undermined in any manner. Additionally, the Cronbach alpha coefficient was used as a measure of internal consistency for the original survey with a value of 0.81 indicating that the survey was both useful and reliable.

Group Differences

The control group and experimental group were considered comparable in their ability levels in mathematics at the beginning of the study. There were no significant differences between groups in terms of age, gender, ethnicity, or socioeconomic status. Measures of students' knowledge in Algebra and Geometry before and after the tutoring intervention were collected. Averages were taken directly from a grade-reporting program at the beginning and end of the six- week period. The results are shown in Appendix G.

Data Collection

No data was collected for the tutors. Pre- and post-intervention data was gathered only from the students who were the tutees. The results were organized, analyzed,

interpreted, and represented in tables and graphs, for a complete report of the data and findings of the researcher. School records were used to gather data for classifying students as high or low achievers. Preliminary results helped to identify tutees and establish tutors so that they could be trained prior to implementation of the tutorials.

A control group and an experimental group were established for this study. The control group did not participate in tutorial sessions while the experimental group underwent six weeks of tutoring in mathematics. Data was collected from tests and surveys. The practice graduation test and MDS were administered to all participants. This information proved critical for examining participants' attitudes toward learning mathematics. Data collection took place prior to the tutoring intervention and at the conclusion of the study. For the purposes of confidentiality, surveys were stored in a locked file cabinet in the residence of the principal investigator. The names were coded and these codes were kept separate from the data.

Data Analysis

The study involved a nonrandomized control group, pretest- posttest design; therefore, ANOVA (analysis of variance) was used in data analysis. Due to the design and population of the study, statistical measures were supported with qualitative data to provide a clearer representation of the overall effects obtained in this study. This mixed methods approach includes quantitative analysis to be followed by thick, rich descriptions of attitudinal categories created by the authors of the original survey.

Transcripts were used to collect students' grades in high school mathematics courses. The grades were used initially to determine whether the students could be identified as

high- or low-achievers. Later the course grades along with test results helped in concluding whether or not the tutorials made an impact on mathematical achievement for tutees. Similar methods were used by Gabriele and Montecinos (2001), in their study involving peer tutorials.

Attitudinal effects were determined using the surveys. Rating the surveys and calculating the weighted averages as determined by the mean distance from optimal yielded an overall score for each respondent. The total of the responses for all of the agree statements was divided by the number of agree responses to obtain an average. One, which is optimal for agree statements, was subtracted from this average to obtain the mean agree distance (MAD). The sum of all the responses to the disagree statements was also divided by the number disagree responses for an average which was subtracted from five (the optimal disagree score). This yielded a result known as the mean disagree distance (MDD). Finally, the mean distance from optimal (MDO) was calculated by averaging the mean agree distance and mean disagree distance for pre- and post-test data from the MDS. Lower MDO scores are indicative of desired outcomes. This is true because the participants were responding in a manner much like the mathematics experts who determined whether the survey items belonged to an agree or disagree category. Final analyses involved use of ANOVA and descriptive analyses to compare pre- and post-test MDO results.

Sampling

Purposeful sampling was employed due to the nature of the procedures and because the study was confined within three course offerings in mathematics at the high school

level: Algebra, Geometry, and Calculus. Initial sampling distributions were based upon student achievement (educational rating) and performance (task completion). Ninety-two students were chosen from the initial population for participation in the control and experimental groups.

Procedures

The overall goal of the tutoring intervention was to afford students the opportunity to interact with one another in an integrated learning environment. In the first segment of the investigation, specific objectives of the peer tutoring program were established by the principal investigator. These objectives were developed with the needs of the tutor and tutee in mind to work toward achieving the common goal. Information was provided for students and parents defining the tutoring program as an intervention to enhance the learning of mathematics. Prospective participants were identified and parents contacted to obtain permission for their child to take part in the peer tutoring program.

The entire peer tutoring research study went through four phases of operation which lasted several weeks. It was necessary to evaluate students' performance in order to establish dyads. In phase one, school records were examined for the purpose of using mathematics grades to identify low and high achievers from the original pool of 200 students enrolled in Calculus, Algebra, and Geometry. Students in danger of failing were classified as low achievers. High achievers were considered as those students who had A averages in mathematics. The principal investigator also assessed each student's willingness to tutor or receive tutoring.

In the next phase tutors were selected and trained. Calculus students with positive

attitudes were recruited as tutors. Selection of cross-peer tutors were made from students who were performing well in AP Calculus with high achievement scores. The Honor Society, which consisted of 80 students enrolled in Calculus and Analysis met the criteria and were available as tutors. Members of the calculus class were asked to sign a roster if they were willing to tutor students enrolled in Algebra and Geometry courses. All members of the Calculus class volunteered and all of them possessed an aptitude for mathematics based upon previous grades and teacher assessments. They were outgoing and sociable individuals with excellent communication skills. This group of students had the qualities necessary for math tutors. These high achievers were trained as tutors for one week prior to the tutoring intervention.

Tutor Training

Selected tutors received training from the principal investigator for one week immediately preceding the onset of the intervention. Methods outlined by Goodlad and Hirst (1989) and and Rabow, Chin, and Fahimian (1999) and adapted from Barfield (1998) were used in the training sessions. These methods included the use of positive feedback by tutors to reinforce competence and confidence in the mathematical skills of tutees and role playing. Role playing on the part of the trainer in which the subject acts the part of a tutee permits correction or reinforcement of tutoring strategies. The peer tutoring program is ready for implementation once the methodology is clearly understood by the tutor and tutee.

Tutors used a four-step mathematics tutoring approach including presentation, instructions, error correction, and social reinforcement (Miller & Kohler, 1993). These

structured procedures were adopted from the earlier study in which significant academic and social gains were evidenced in elementary school children. Throughout the six-week tutoring period tutors were encouraged to keep a journal for self-evaluation. This provided useful assessment as they recorded successful as well as unsuccessful assistance techniques in their journals.

Tutee Selection

Once training was complete, the next phase was for the tutees to be selected. Current grades were scrutinized to determine which students were failing the course and might benefit from tutoring. Only those students who were willing to work, but were not performing well in Algebra or Geometry would be considered as tutees for tutorial sessions. However, students with both positive as well as negative attitudes towards mathematics were considered as tutees. Students who were examples of prime candidates to receive tutoring included students who were at-risk of failing the course and who exhibited feelings of math anxiety.

The students enrolled in Algebra and Geometry courses were polled to see if they were interested in being tutored. Forty-six students signed lists indicating that they were interested in attending mathematics tutorials. A brief orientation session in a social setting was held two days later and less than half of the prospective tutees were in attendance. Some initial pairs were established although adjustments were made as necessary or as requested because some of the tutors preferred to help with Algebra rather than Geometry. The majority of the AP Calculus students who agreed to tutor their peers said they felt more capable of assisting students with algebraic skills rather than

geometric concepts. The tutors explained that they felt this way because they had taken Geometry in middle school and the course content was not as easily recalled as Algebra, which was studied more recently during their high school years. Overall, the tutors felt that Algebra was an easier subject than Geometry.

Dyad Formation

Dyad formation is a crucial part of a peer tutoring intervention (Topping, 1988, Fuchs, et al, 1997). The goal of the selection process for this study was to pair a student who excelled in mathematics with a student who was experiencing difficulty. One aim was to enhance skill performance and conceptual knowledge in the subject. Careful selection of the dyads afforded the clearest picture as to the effects of the program on individuals chosen and the results obtained after completion of the study. Once dyads were established and the tutors were identified and trained, the tutoring began.

Tutorial Sessions

The actual tutorial sessions were at the center of the next phase. Thursday afternoons were the days most students agreed upon for the tutoring sessions to be held. The students worked after school for one hour every Thursday for six weeks. The tutorial sessions were held in several classrooms after school. The investigation took place during the Winter semester and there were many school activities planned. Students had orchestra rehearsals, basketball tournaments, the Valentine's Day dance, and many other school functions to attend making it necessary to allow some flexibility in the pairings. It should

be noted that every part of the school year is replete with student activities and that mostly higher level students participate in them as a rule. If a conflict arose, the tutors would occasionally substitute for each other. Some days there were different students working with one another, however they still worked effectively.

The tutorial sessions were ongoing and lasted for a period of six weeks. Data was collected during the first and sixth weeks of the study. Each participant in the control and experimental group completed a Mathematics Disposition Survey and an appropriate mathematics skills test. Mathematics Disposition Surveys were used to examine students' attitudes toward learning mathematics. The same survey and test was administered at the beginning and end of the investigation The final segment of the investigation involved re-examining students grades upon conclusion of the tutorials and post-intervention survey results. This was done to determine whether the intervention had an impact upon students' mathematics grades and their attitudes towards mathematics.

Summary

The current study employed a quasi-experimental design because this approach best answers the questions which guide the research. Quantitative methods of data collection used for the selection of dyads were followed by qualitative methods of investigating the attitudinal impact of the tutorials. The focus was only on the impact on tutees not the tutors. As trained calculus students tutored students in prerequisite mathematics courses, it was anticipated that student scores in mathematics would increase. It was also hypothesized that students' attitudes towards learning mathematics would improve as a result of these tutorials.

Subsequent chapters unveil the results of this research investigation and implications for future research studies. Every classroom is unique and the strategies used for this study may require modification for use within a specific class setting. Teachers should conduct further research and identify those techniques which work best for their particular design, learning environment, or student population before implementation of any type of peer tutoring program.

CHAPTER 4

RESULTS OF THE STUDY

This empirical study investigated the impact of a six-week, one to one session of peer tutoring on students' academic achievement in Algebra or Geometry and their overall attitudes towards learning mathematics. Specifically, the study sought to determine whether or not participation in peer tutorials had a predictive effect on student achievement on an exit examination or students' mathematical attitude on the Mathematics Disposition Survey (MDS). The participants included 138 students from a high school population of approximately 2200 students in a suburban area of a major southeastern city. Forty-six Advanced Placement Calculus students served as tutors, 46 students enrolled in Algebra or Geometry made up the experimental group, and the control group was comprised of 46 students who did not participate in peer tutoring but were likewise enrolled in Algebra or Geometry classes.

Overall Results from this Research Study

There is clear evidence that the use of a peer tutoring component as a part of the mathematics curriculum would be a valuable tool in improving student test scores in the area of high school mathematics. This may generalize to other subject areas as well. The pre- and posttest scores are very clear in delineating this improvement across the board. Some changes in the tutoring process have been identified and may alter the process in future uses for this program by the researcher.

As for the improvement of the attitudes towards mathematics for each of the groups, the picture is not so clear and bright. With all the mathematics classes previously taken by the students, using various approaches and methods to different degrees of success, it is hardly likely that a six-week tutoring intervention would change attitudes to a great degree. However, promising results were achieved in the area of memory in mathematics. This is the part of instruction which is basic to all content areas and should be emphasized with the tutoring process. As for student attitudes towards mathematics, there is an intrinsic value to earning higher grades in a particular subject area. As the student's grades rise, they tend to like the subject more which tends to increase their efforts and promotes even higher classroom performance. Tutoring may become a self fulfilling prophecy for students improving their overall attitudes and skills in the future.

Pre-Post Achievement Scores

As a mathematics education researcher, the concrete scores from this part of the investigation are more conducive to analysis and discussion. Both tests were administered in the researcher's classroom setting at six-week intervals. The conditions for the test takers were identical and no outside support was provided by anyone at any time. For the purpose of clearer, more significant results, a 25-problem mathematics test was used as one of the required instruments.

To determine main interaction effects, repeated measures analysis of variance was used and followed by further tests based upon the level of significance. The peer tutoring intervention had a significant impact on the achievement scores of the tutees as indicated by a one-way ANOVA. The results which were significant are shown in Appendix F

($\alpha = 0.000$). The six-week tutoring intervention had a significant overall effect on students' mathematical achievement on the high school graduation practice test.

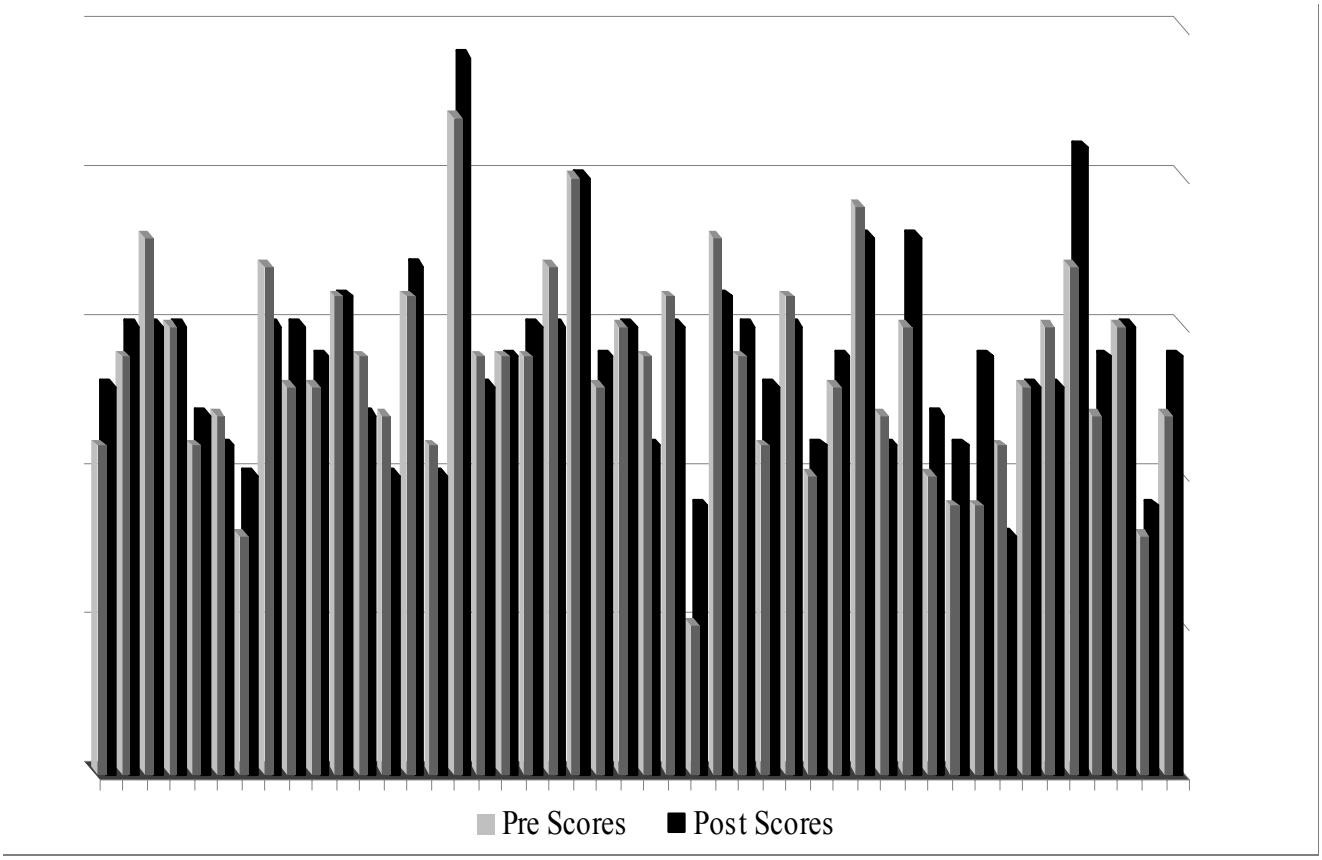
For the purpose of this discussion, the results for each group on both tests will be shown and followed by a careful analysis of what was observed by the researcher.

Table 3

Pre-Post Achievement Scores for Control Group (# correct out of 25)

Pre-test	Post-test	Difference	Pre-test	Post-test	Difference
11	13	+2	14	11	-3
14	15	+1	16	15	-1
18	15	-3	5	9	+4
15	15	0	18	16	-2
11	12	+1	14	15	+1
12	11	-1	11	13	+2
8	10	+2	16	15	-1
17	15	-2	10	11	+1
13	15	+2	13	14	+1
13	14	+1	19	18	-1
16	16	0	12	11	-1
14	12	-2	15	18	+3
12	10	-2	10	12	+2
16	17	+1	9	11	+2
11	10	-1	9	14	+5
22	24	+2	11	8	-3
14	13	-1	13	13	0
14	14	0	15	13	-2
14	15	+1	17	21	+4
17	15	-2	12	14	+2
20	20	0	15	15	0
13	14	+1	8	9	+1
15	15	0	12	14	+2
		Totals	624	640	

Figure 3. Pre-post achievement scores for control group



The mathematics test devised was taken from materials used to illustrate typical problems on the state high school graduation test. There are four strands on the state-wide test and the 25 questions on the practice test that was used in the study were correlated and may be categorized accordingly:

Strand 1- Number & Computation #1, 3, 12, 14, 17

Strand 2 - Data & Analysis #4, 7, 8, 10, 11, 13, 16

Strand 3 - Measurement & Geometry #6, 21, 22, 23, 24, 25

Strand 4 - Algebra #2, 5, 9, 15, 18, 19, 20

Overall these results may indicate a general lack of academic mathematical improvement for this control group of students. Most of the post-test scores were within plus or minus two points of their original scores. Notable exceptions may be explained in several cases by the low initial scores obtained on the pretest with 16 students scoring even lower on the posttest and the others improving to a respectable level. The few students who dropped three questions may not have tried their best or made careless errors. The scores remained relatively constant with a mean score of 13.74 from pre-test to post-test for this group. The wide range of pretest scores (5 to 22) is indicative of the random nature of the composition of this group. The fact that there was minimal improvement over the six weeks, even with classroom instruction was not a primary focus of this research.

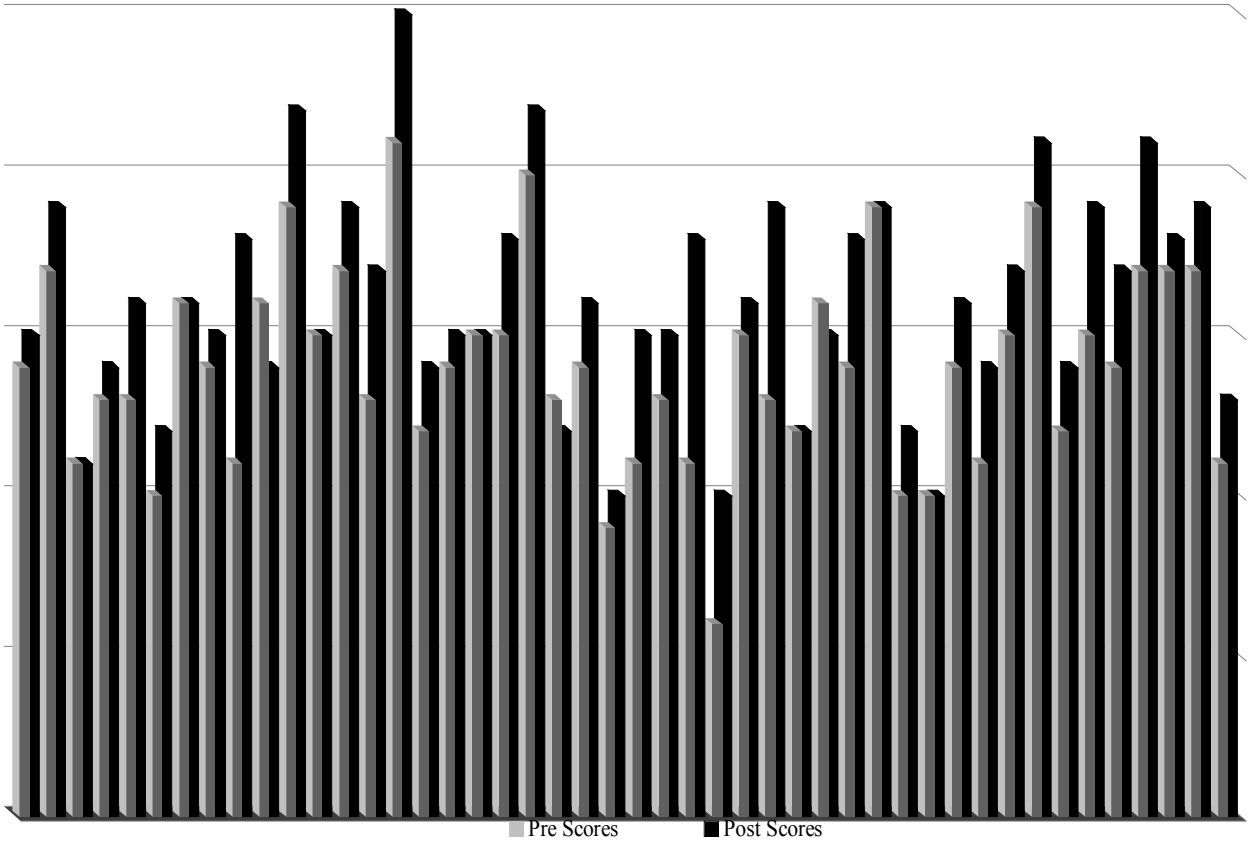
Table 4

Pre-Post Achievement Scores for Experimental Group (# correct out of 25)

Pre-test	Post-test	Difference	Pre-test	Post-test	Difference
14	15	+1	11	15	+4
17	19	+2	13	15	+2
11	11	0	11	18	+7
13	14	+1	6	10	+4
13	16	+3	15	16	+1
10	12	+2	13	19	+6
16	16	0	12	12	0
14	15	+1	16	15	-1
11	18	+7	14	18	+4

16	14	-2	19	19	0
19	22	+3	10	12	+2
15	15	0	10	10	0
17	19	+2	14	16	+2
13	17	+4	11	14	+3
21	25	+4	15	17	+2
12	14	+2	19	21	+2
14	15	+1	12	14	+2
15	15	0	15	19	+4
15	18	+3	14	17	+3
20	22	+2	17	21	+4
13	12	-1	17	18	+1
14	16	+2	17	19	+2
9	10	+1	11	13	+2
		Totals	644	738	

Figure 4. Pre-post achievement scores for experimental group



There were 46 cases at each factor level with tutoring as the within subjects factor. Four measurements were taken for all participants: pre-achievement, post-achievement, pre-attitude, and post-attitude. The control and experimental groups were comparable as supported by a comparison of the means from the results of independent samples t-tests. The tests yielded a significance value of .519 for the pre-achievement scores (see T-Test 1), thus indicating that there was not a significant difference between the two group means prior to the intervention. After the tutorials, achievement scores for both groups increased. The control group scores increased from 13.57 to 13.91 and treatment group scores increased by a greater margin from 14 to 16.04. In contrast, a significance value of .002 for the post-achievement scores was indicative of a significant difference between the group means after the treatment.

Attitudinal effects of the intervention were not significant which can be seen by the results shown in T-Test 2. The significance value of .279 indicates the means were not significantly different initially, nor were they after the treatment with a post-attitude significance value of .359. However, a general linear model showed that the interaction effects of attitude and achievement were significant (.000) and the interaction effects of attitude, achievement, and group were significant (.000). It is noteworthy that pre-post attitude averages which are displayed in T-Test 2 increased for the control group (2.0387-2.0576) yet decreased for the treatment group (2.1080-1.9980), which is desirable since the measure taken was the Mean Distance from Optimal (MDO) thus indicating the treatment group was closer to optimal or to positive attitudes towards mathematics.

Table 5

Group Statistics for Achievement Scores

Measure	Group	Mean	Standard Deviation
Pre-test	Control	13.57	3.34
	Treatment	14.00	3.10
Post-test	Control	13.91	3.13
	Treatment	16.04	3.38

Table 6

Independent Samples Test fpr Achievement Scores

Measure	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Significance	t	Significance	Mean Difference
Pre-test	.212	.646	-.648	.519	-.43
Post-test	.778	.380	-3.136	.002	-2.13

Table 7

Group Statistics for Attitude Scores

Measure	Group	Mean	Standard Deviation
Pre-test	Control	2.0387	.3119
	Treatment	2.1080	.2990
Post-test	Control	2.0576	.3139
	Treatment	1.9980	.3060

Table 8

Independent Samples Test fpr Attitude Scores

Measure	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Significance	t	Significance	Mean Difference
Pre-test	.067	.796	-1.089	.279	-.069
Post-test	.128	.721	.921	.359	.060

Table 9

Tests of Within-Subjects Contrasts for Achievement Scores

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Ach	13986.412	1	13986.412	1445.152	.000
Ach * Group	37.543	1	37.543	3.879	.052
Error (Ach)	871.035	90	9.678		
Att	30.429	1	30.429	30.889	.000
Att*Group	14.110	1	14.110	14.324	.000
Error (Att)	88.661	90	.985		
Ach*Att	35.427	1	35.427	38.481	.000
Ach*Att*Group	19.147	1	19.147	20.797	.000
Error (Ach*Att)	82.857	90	.921		

Table 10

Tests of Between-Subjects Effects for Achievement Scores

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Intercept	24837.888	1	24837.888	2589.202	.000
Group	38.133	1	38.133	3.975	.049
Error	863.359	90	9.593		

The final results bode well for the future use of this research intervention in the remediation and preparation of our mathematics students for their success on the state high school graduation test – an important facet of their high school careers. In assessing

the effect of the tutoring on the attitudes of both groups, a mathematics disposition survey was administered to both groups at the beginning of the study and at its conclusion. The students were not told their test scores prior to their taking the surveys which may have altered their responses both positively and negatively. Scores were further examined in an attempt to see if there was any correlation between academic achievement with and without tutoring and the student's attitude towards the study of mathematics.

Pre-Post Attitude Surveys

Repeated measures analysis of variance was used to determine main interaction effects; then, based upon the level of significance, further statistical tests were necessary. To ascertain whether or not the peer tutoring intervention had a significant impact on the attitudes of the tutees, a one-way ANOVA was conducted. The results which are displayed in the Appendix F yielded no significant results ($\alpha = 0.208$, $\alpha = 0.076$). The six-week tutoring intervention did not have a significant overall effect on students' attitudes towards learning mathematics. All of the data gathered from the students' responses to the surveys yielded the following results.

Figure 5. Pre-post attitude scores for control group

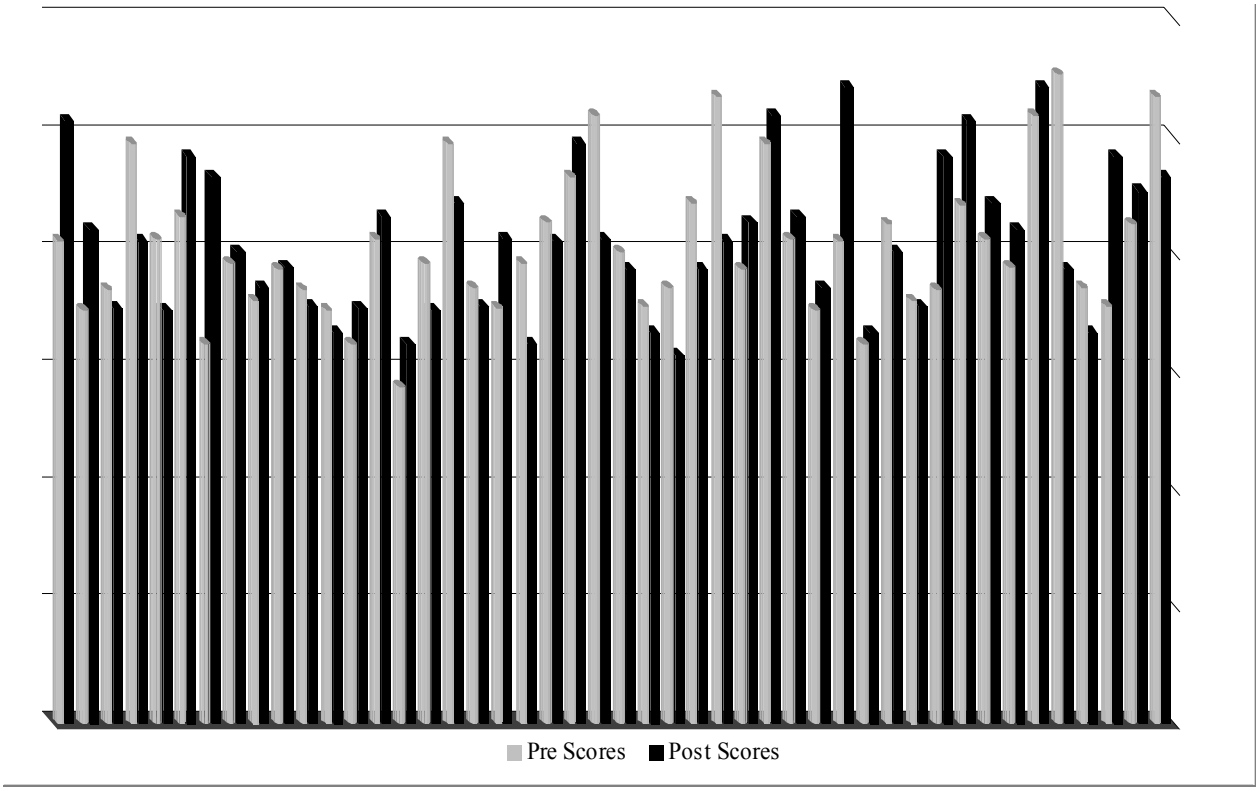
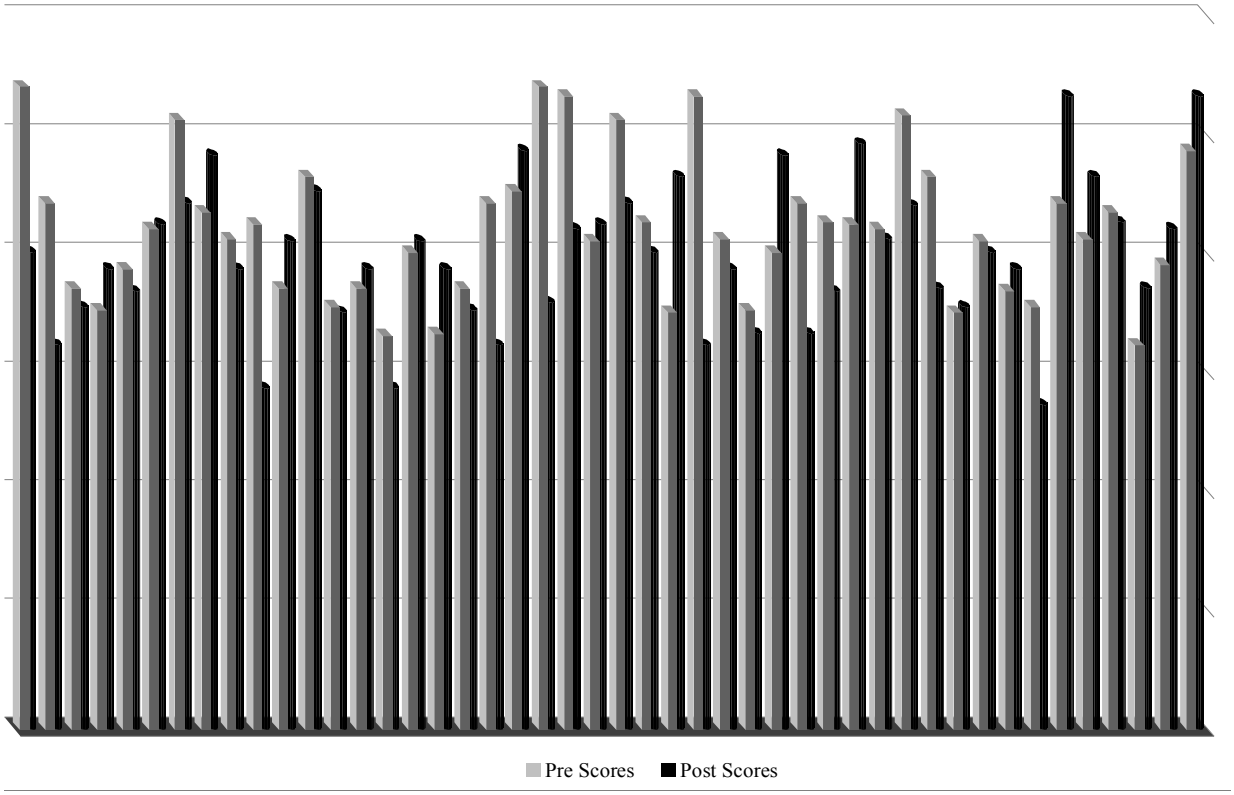


Figure 6. Pre-post attitude scores for experimental group



Experimental Group Results from Pretest of MDS

Table 11
11 Agree Statements

3	**4**	**7**	**10**	**16**	**23**	**24**	**25**	**29**	**30**	**31**
4	4	3	2	4	2	3	4	3	4	2
3	5	3	2	3	1	3	X	4	2	3
1	5	3	1	4	X	5	4	4	4	2
5	4	5	1	1	4	4	2	2	1	2
2	4	4	2	2	3	2	2	2	1	2

Table 12
20 Disagree Statements

1	**2**	**5**	**6**	**8**	**9**	**11**	**12**	**13**	**14**	**15**	**17**	**18**	**19**	**20**	**21**	**22**	**26**	**27**	**28**
2	2	1	2	2	2	2	3	4	2	4	1	2	1	2	2	4	3	4	2
5	5	3	2	1	3	3	3	4	5	3	3	3	2	3	3	4	4	4	4
2	1	4	1	3	2	2	1	2	2	4	2	5	5	3	4	1	5	4	4
1	2	4	5	2	1	1	5	3	5	5	2	2	5	4	4	2	3	5	3
3	2	2	2	2	2	2	2	2	3	1	3	1	3	1	2	3	1	2	4

Table 13
Mean Distance from Optimal

MAD	**MDD**	**MDO**
2.1818	2.65	2.416
1.9	1.65	1.775
2.5	2.15	2.325
1.6363	1.9	1.768
1.3636	2.85	2.1068

Four hypotheses were tested at the 0.05 level of significance: 1) There is no difference in the mathematical achievement of students who participate in peer tutoring and students who do not participate in peer tutoring in mathematics, 2) Students who participate in peer tutoring will have higher achievement scores in mathematics than students who do not participate in peer tutoring, 3) There is no difference in the mathematical attitudes of students who participate in peer tutoring and students who do not participate in peer tutoring in mathematics, 4) Students who participate in peer tutoring will have more positive mathematical attitude scores than students who do not participate in peer tutoring in mathematics. This may be represented symbolically as:

$$H_1 : \mu_1 = \mu_2$$
$$H_2 : \mu_1 \neq \mu_2$$
$$H_3 : \mu_3 = \mu_4$$
$$H_4 : \mu_3 \neq \mu_4$$

and formally stated as:

Hypothesis 1: The first null hypothesis states the means of the achievement scores are equal for the control and experimental group. In other words, the students who participate in peer tutorials will have the same results in achievement as students who do not participate in the tutorials.

Hypothesis 2: The alternative hypothesis states the means of the achievement scores for the control and experimental group are unequal. This implies that the students who are tutored will experience different achievement results than those who are not tutored.

Hypothesis 3: The second null hypothesis states the means of the attitude scores are equal for the control and experimental group. Stated differently, this outlook suggests that tutoring participants will have the same attitudes as students who do not participate in the tutorials.

Hypothesis 4: The alternative hypothesis states the means of the attitude scores for the control and experimental group are unequal. This implies that the students who are tutored will exhibit different mathematical attitudes than those who are not tutored.

Conclusions

Data on mathematics skills and related attitude was collected during the first and sixth weeks of this study. Each participant in the control and experimental group completed a Mathematical Disposition Survey and a test. The same survey and test was administered at the beginning and end of the investigation. No data was collected for the tutors as the tutees were the focus group for this study. Individual participants showed only a slight change in their MDO results on the survey. The individual achievement scores from the 25-item practice graduation test based on pre- and post-test outcomes were higher for the tutored group of students.

Independent samples t-tests provided a comparison of the means of the control and experimental groups and were followed by repeated measures multivariate analysis of variance MANOVA, which revealed significant main effects. Therefore, two separate repeated measures ANOVA were conducted using achievement and attitude as the dependent variables. There were two measures taken on achievement: pre-achievement

and post-achievement and pre-post measures on attitude were taken for all participants. There were 46 cases at each factor level. Interaction effects of pre-tests, post tests, and group were highly significant with an F statistic of 11.236 and p-value of .000. Univariate tests show that attitude scores were not significant.

Profile plots clearly show a steeper rise in the scores of the treatment group, however for practical purposes, the difference in minimal. Achievement margins range from a difference of approximately 0.4 to 2.1 between groups. The graph displays the estimated mean for the control group at 13.6 initially and 14 for the treatment group, thus a difference of 0.4. After the intervention, the estimate of the control group mean was 13.9 and 16 for the treatment group which is a difference of 2.1. Both achievement and attitude scores for the control group remained relatively constant, however, the treatment group experienced an increase in achievement.

Figure 7. Relationship between pre- and post achievement scores for control and experimental groups

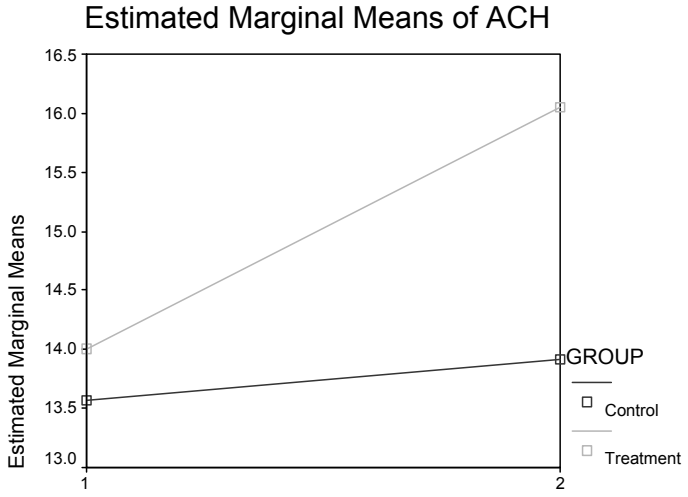
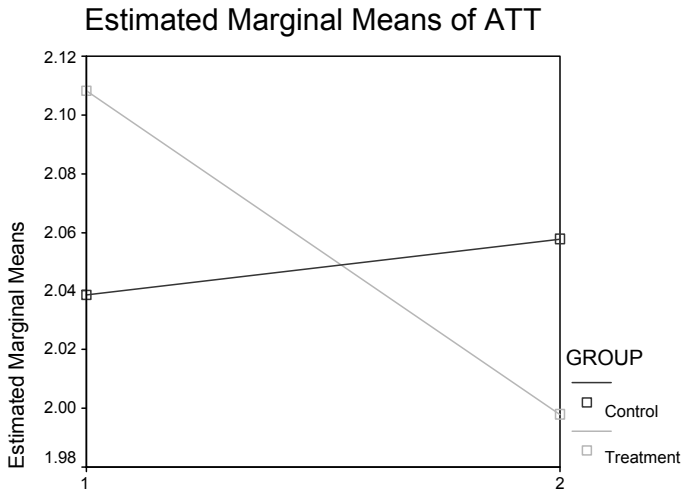


Figure 8. Relationship between pre- and post attitudinal scores for control and experimental groups



The second graph clearly shows a rise in MDO attitude scores for the control group, but a decline for the treatment group. Declining MDO scores are indicative of favorable attitudes.Therefore, this decrease can be interpreted as more positive attitudes towards mathematics, however this change was also minimal.

Both null hypotheses were rejected because the significance value in Mauchy's Test of Sphericity is less than .05, therefore sphericity can not be assumed.

Table 14

Mauchly's Test of Sphericity fpr Attitude Scores

Mauchly's W	Chi-Square	df	Significance
1.000	.000	0	.000

The study revealed the following: 1) Participation in peer tutoring has a predictive effect on increasing mathematical achievement, specifically on the high school graduation test. 2) Participation in peer tutoring does not significantly raise students' mathematical attitude scores.

Summary

This study demonstrated the potential for peer tutoring to provide a means of enabling students to be more successful in Algebra and Geometry courses and to have more positive attitudes towards learning mathematics. Statistical tests indicated that the control and treatment groups were comparable in that their mean scores were not significantly different on pretest measures of achievement or attitude. Although after six weeks of tutoring, the attitudinal means remained relatively close between the two groups, there was a significant difference between the means with regard to achievement results.

Four hypotheses were tested and the outcome of the investigation revealed that peer tutoring does appear to have a predictive effect on student achievement in mathematics but not on their overall attitude towards learning mathematics in general. Due to the potential benefits of peer tutoring in an educational atmosphere where increased achievement scores are the benchmark of effective schools, the following chapter poses suggestions for continued research in this critical area.

CHAPTER FIVE

FINDINGS & IMPLICATIONS FOR FURTHER STUDY

This chapter includes a discussion of the findings of this peer tutoring study, how these results correlate to the literature and suggested paths for future research investigations.

Discussion

Before any discussion of the tests and surveys can be conducted, the researcher must conduct a careful scrutiny of the experimental and control groups used in the study. While some critics may believe that the use of only 46 students in each of the groups may limit the scope of this research, the in-depth analysis of the data should produce a very clear picture of the scope and importance of the results obtained. The significance of the conclusions reached may have consequences for today's instruction and future research.

Although a true randomness was not possible with the intervention of the tutoring component, the groups were comprised of individuals who were assigned to a group based solely on the volunteering for tutoring and the non-volunteering students involved. No other criteria were used in the initial formation of these groups. One aspect of this research that was not addressed was "WHY?" the students chose to be included in the tutoring group. This may have been due to past grades, a doubt in one's ability to do well in the subject, academic interest or even parental pressure. It is also likely that the group

that did not volunteer may have had their own set of external reasons for their choice. These outside forces were not fully discernable in the pretest and survey scores.

As for the composition of the groups, several exclusionary factors need to be addressed in order to show the fairness of the selection and the highest degree of randomness achieved by the researcher. The groups were composed of both male and female African American students within the same age group enrolled in the same academic courses at a suburban high school. There were no non-English speaking or special education students included which would skew the outcomes. All of the students were upper level, college bound students who were each offered the opportunity to be part of the tutorial process. No apparent socio-economic differences in the group were evident to the researcher.

MPEX Survey

As this study is considering the attitudes of the subjects towards the beliefs and instruction of mathematics, a way to determine affective changes was needed. Furthermore, the data needed to be rendered understandable to persons not necessarily trained in the area of mathematics so that further research and actual application could occur. This concept was elucidated by Redish, Saul, & Steinberg (1998), in a study which formed the basis for the survey chosen for this research. Their MPEX survey looked at the attitudes of students towards the study of physics and chose this method because "unlike many research-based methods, they can easily be used and interpreted by instructors who are physics educated researchers." (p. 139). An adaptation of their work was chosen as the most effective way to ascertain the significance of my findings.

In the physics study, Redish, Saul, & Steinberg (1998) used a 34-item Likert-scale (agree-disagree) survey that probed the students' cognitive expectations and this study had similar goals in mind. The research model was based on the work of Redish and Steinberg at the University of Washington in 1993. They rated attitudes on a five point scale, from (1) strongly agree to (5) strongly disagree, and this research adopted the same scale. To accommodate the number of responses and insure to accuracy, a scantron version of the survey was developed and used with the high school students. The survey contained 31 items and typically took the students 20 to 30 minutes to complete.

The cognitive beliefs that are referred to as student expectations and feelings are complex and contain many facets of learning and individuality. The MPEX survey focuses on six issues or dimensions which categorize student attitudes about learning physics and also the subject of mathematics. Redish and Steinberg's cluster descriptions were outlined and adapted for the purposes of this study.

The first dimension of the MPEX survey was in the area of Independence and explored the beliefs about learning the subject through receiving information and reconstructing one's own understanding. In this investigation, the concept most closely associated itself with the memory aspect of learning mathematical materials and adapting this process to performing mathematical functions.

Next on the list was the area of Coherence or basic beliefs about the structure of the subject and the isolated pieces of the system. Within the study of mathematics, it was felt by the researcher that this domain crossed over many categories and did not lend itself to a close specific examination. The study of the individual steps in the mathematical

process was beyond the scope of this investigation and may lend itself to a separate more distinct study for future research.

The third dimension was called Concepts and dealt with the concepts of the physics knowledge or the formulas which underlie the formation of basic concepts. The present study chose to use the area of general mathematical knowledge as the corresponding aspect of the overall research. As the subject of the study was a higher level mathematics application, prior knowledge of information addressed through earlier years was a key ingredient in the formation of a solid understanding of the subject matter.

The Reality Link was the next aspect chosen by the MPEX authors for examination. The attitude of the subjects regarding beliefs on the connection between physics and reality or the relationship to experiences outside the classroom and whether it was useful to think about them together was addressed. This was a vital component to the study about the student's expectations for the application of mathematics to their own lives as demonstrated in the survey. The section was entitled the "The Relation to Life" as was a significant aspect of this research.

The Math Link was the most closely identified aspect of both surveys. The MPEX survey measured the application of formal mathematics to the calculation of numbers or a way of representing information about physics. The survey chosen for this tutorial study was more closely related to the practice of mathematical functions as a way of increasing the ease of manipulation of the process and internalizing the higher level concepts. A direct relation came to be made for the acquisition of these basic content skills.

The last domain addressed by Redish and Steinberg's research was broadly labeled "Effort" which encompassed the kind of activities and type of work necessary to make

sense out of physics. This category included the ability "to think clearly and evaluate what they were doing based on available materials and feedback" (Redish, Saul, & Steinberg, p. 144). The category related directly to this research which looked at the student's beliefs about classroom instruction and the use of the textbook. The close examination of the actual effort put forth by the students would not be possible using the instruments designed for this study. As effort is such a complex and indefinable term, only general conclusions about this topic can be inferred from the survey used.

While other research may have been used to guide the study, it was felt by this researcher that this one in particular most closely aligned our examination with this previous work. While it is not exact, it does accurately portray the data derived and supplies a design from which a useful pattern can be derived for present application in the schools and for future study.

Mathematical Disposition Survey Categories

Before any further attempt is made to analyze the changes in attitudes on the part of the students included in this study, a method needs to be devised which would provide an accurate look at academic attitude towards the subject of mathematics from a slightly different perspective. For this approach, using all of the data collected (5,704 answers to surveys) would prove ponderous and time consuming and the picture of overall attitudinal change would be murky and confusing at best. Therefore, the survey questions were broken down into five distinct categories and identified by number and content. For this discussion, the control group members that did the best as far as improving their score were used. When the improved scores were the same for

individuals, the higher test scores were chosen. These descriptions were framed by the individual average given for the statements in the group. The scoring range of responses for the survey items used was:

1- Strongly Agree 2-Agree 3-Neutral 4- Disagree 5-Strongly Disagree

The first category of survey items devised was that of General Mathematical Knowledge and included statements which dealt with past learning and skills. The statements and their relative content were:

General Mathematical Knowledge

---

1) formula is valid 2) matching problems with facts 3) understanding derivations

9) applying information 13) trusting results 15) capable of understanding math

19) approaches to a problem 22) purpose of studying math 25) underlying concepts

29) reasoning logically 30) mistakes as clues 31) knowing what terms mean

---

I read each response and listed the scores of these items for each student. The mean was derived for this category on the pre-survey given before the intervention and six weeks later on the post survey, then the difference or change was established.

As can be seen from the two research groups chosen, a marginal change in the direction of agreement was reached for the treatment group. This indicated that the overall attitude of students in the group agreed that the basic concepts and their usage were important and they could likely agree on their merits. The nature of the results indicated a larger improvement in the group that was tutored over the control group. The

overall trend to a more positive attitude is likely due to effective classroom instruction, improved grades and to some degree more comfort with the mathematical concepts and skills. The number of items involved may have weakened the picture with high scores only in certain areas which would have skewed the final results of the study.

The Effect of Mathematical Classroom Instruction and Use of Textbook

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10) information given in class 12) acquiring knowledge in class
14) deriving proofs in a course 21) using exam results 23) passing a math course

---

This section of the research deals with the students' attitudes towards how mathematical instruction is provided for the participants in the researcher's classroom, in addition to the classes they had previously taken. Also included within this discussion is the student and teacher use of the textbook as it is an intrinsic part of the daily curriculum. An evaluation of the textbook used was not a part of this research. However, it is a widely used, well respected text in the field. The instructor has had over 27 years teaching mathematics at the high school level and is highly qualified in this area. The teacher's professional evaluations which were routinely conducted by administrative personnel over the years point out expertise in this field.

As can be seen by the scores, there was a scattering of attitudes towards the effects of instruction and use of text materials. In the control group, many of the students felt more in agreement with the positive learning from both sources. However, some of the students tended to disagree to a significant degree with the importance of this aspect. In the tutored group, some of the students also agreed with the significance of the teacher and

text and others slightly moved towards disagreement. On the surface, the numbers look very similar but an inclination may be arising for the positive.

The Relation of Mathematics to Life

7) mathematics and the real world	8) achieving career goals
16) relating situations in everyday life	20) connection to real world
24) understanding life situations	

As with most academic subjects taught in our schools today, the community wants to know how the curriculum relates to the students' present and future lives. This becomes an important aspect of the overall attitude of all the research group's participants. As educators, it is of utmost importance for us to make what we teach relevant to the lives of those we teach.

There was little difference in the attitudes of both groups in this category or any significant change after the intervention. This may have been due to the instructional emphasis placed in the classroom. An overall shift to the positive was evident in the data but there was not a higher range for the experimental group. This may be a salient point which could be added to future tutoring groups which could better relate sessions to practical life experiences. There were very few scores which advanced towards disagreement on the topic.

The Direct Relationship of One's Memory to Understanding Mathematics

5) equations and definition given	11) memorizing facts and procedures
17) finding the right equation	18) remembering equations
26) recall something read	28)memorize required information

As with most academic subjects the importance of memorizing has a direct relationship to one's ability and skill level achieved. These questions dealt with the ability of the students to recall information in order to solve mathematical problems.

There was a significant discrepancy in the results obtained for these two groups. While the control group had a few students that stayed the same and others that edged towards the disagreement of memory importance, most of the tutored group seemed to have agreed that memory was a direct indicator of their learning. Perhaps the extra time spent with their tutors developed their ability to remember information and definitions which they later used to improve their overall test scores. This should be noted for future researchers as a point of emphasis in their intervention.

The Importance of Practice in Learning Mathematics

4) work through many math examples	6) solving many problems
27) spending a lot of time on a problem	

There was very little change in the attitude of either group relative to the importance of practice in the acquisition of mathematical skills. Practice and mathematics are unequivocally linked. Of all the questions studied, this area showed the least significance in the improvement of attitude on the parts of both groups. This may be explained by the general attitude of most students who seek instant gratification and eschew the desire or appreciation of practicing in order to perform better.

Empirical Studies & Future Research

Future research studies on peer tutoring should involve parents, students, and teachers of varied disciplines. They all play a major role in producing capable students and future mathematicians. Parenting entails fulfillment of basic needs and encouragement. Inspiration to achieve or succeed in educational endeavors may stem from parents and other people who are significant in our lives. Peers are certainly capable of inspiring one another. As social beings, working with peers can be naturally productive instead of working independently. This is true not only for students, but teachers as well.

Genovese, Hursh, Jitendra, and Lupton (2005) recognized the need for improvement in our schools. Through a grant sponsored by the National Council of Teachers of Mathematics and Toyota, Arbaugh (2003) facilitated a study group comprised of high school geometry teachers. They focused reform efforts within two areas of concern: pedagogy and curriculum. The teachers involved in the study group have continued to find ways of supporting sustained collaboration with their peers. The bonding which occurred among their peers in the study group was such that the teachers wanted to continue the correspondence. As a direct result of this opportunity for professional growth, teachers remarked that they were able to re-enter their classrooms with new

ideas about teaching mathematics which would enhance student abilities and would result in increased achievement levels. All teachers and students would benefit from such rejuvenation in our schools.

This study and others discussed throughout have supported the use of peer tutoring to increase performance and achievement. Achievement gains are indicative of successful academic programs. Schools that have high achieving students are the schools of choice for many families. Report cards are available for some schools so that interested persons may become acquainted with the progress or lack of progress of these schools. Teachers are committed to educating students to broaden their future and teachers are also concerned with the students' performance on standardized tests and the reflection of these results on the individual school.

High-stakes tests such as graduation tests and end-of-course tests pose a concern for parents, teachers, and students. The results of Early's study clearly demonstrated the promise of peer tutoring programs in improving standardized test results. This investigation extended the time frame of Early's research and supports the implication that longer tutoring periods will increase the success of the intervention. The results of this study were similar to those obtained by Early, but the subjects were older students enrolled in specific high school mathematics courses.

The formation of dyads in Barfield's study was examined closely as a model for this investigation. Dyads were determined using Barfield's approach, however, because the circumstances were not the same, a few of the students were not paired with the same tutoring partner for the duration of the study. The results were not likely skewed by this deviation because the general characteristics of all the tutors were comparable in nature.

Further study on the verbal exchange between participants in peer tutorials should be conducted. Gabrielle and Montecinos (2001) hypothesized that low-achieving students were likely to passively agree with their high-achieving partners in problem solving situations. However, their hypothesis was not supported. There was not a notable difference in the participation in terms of verbal exchange of the low achievers or high achievers and their partners. The context and amount of the verbal exchange between tutoring pairs could lead to valuable implications for tutoring programs within our schools. The conversations that the peers have during tutorial sessions are as important as the mathematical skills that are enhanced by additional practice and support. It is during these discussions that the tutor's positive attitude toward mathematics is likely to shine through, and thereby influence the tutee.

Some school communities have a problem with diminishing achievement and poor attitudes towards learning mathematics. Rather than six weeks of tutorials, a longitudinal study over the course of a semester or an entire school year would provide more insight into this problem of student's negative attitude towards mathematics, particularly with the use of repeated measures. In order for students to excel in mathematics, they need guidance from all members of the educational and family communities.

Just as the study group of geometry teachers benefited from collaboration with their peers, students could also build ongoing learning relationships. Studies have shown that both tutors and tutees can benefit from the interaction (Griffin & Griffin, 1997). Not only will the students receiving tutoring be helped, but the tutors will also benefit from the tutorials. These tutors have the opportunity to review and refresh some of the basic mathematical concepts that may not have been currently in the forefront of their

minds. They can relearn and reinforce their understanding of the basic concepts of mathematics by tutoring their fellow classmates.

This study did not focus on gains for the tutors in the process. However, future studies should be conducted to explore the benefits derived from the teaching process. Peer tutoring programs may not be widely used throughout educational systems today but could be helpful to many students in a variety of ways. These programs need to be tailored in order to more effectively meet the needs of our diverse student population. The control group, experimental group, and group of tutors in this study each contained 46 students for a total of 138 participants. Future studies should be conducted that involve 150 students in each group and extend over longer periods of time such as a semester or a year-long study. Conducting additional research can assist schools in creating effective tutoring programs which are tailored to the particular needs of their neighboring community.

Awareness of the surrounding community is essential for educational support. Changes in family structure and community institutions have placed the school system in the position of assuming greater responsibility for meeting the psychological and educational needs of our students (Fantuzzo & Rohrbeck, 1992). To successfully meet this challenge, educators must employ a wider variety of methods that would increase student achievement. Time and resources must be allocated so that teachers can devise plans to stimulate learning experiences.

Teacher Planning

Focusing on how, what, when and why learning occurs enables teachers to more effectively plan instruction and educate our future generations. A better understanding of the way in which students form their knowledge base and what factors contribute to their attitudes will permit educators to do more in re-evaluating their instructional strategies. If teachers design a survey similar to the one utilized in this research, it would provide insight into their students' attitudes toward learning. Student responses to categorical questions such as those described in Chapter 4: Instruction and Use of Textbook, Relation to Life, and Importance of Practice, can provide evaluative tools for teachers. The evaluation of these responses can guide teachers toward developing lesson plans that prompt students to recognize the practical application and real world connection of the subject matter presented before them.

Teachers may be able to carefully plan their lessons with these ideas in mind and studies such as this can help them make the necessary adjustments to meet the educational needs of more individuals. Peer tutorials with close monitoring can target problem solving difficulties that students encounter of which the teacher was previously unaware. Students are not always aware of their deficiencies in mathematics and other subjects. Working with another individual may bring difficulties and attributable factors to the forefront. If students are already cognizant of their shortcomings they are more likely to be relaxed enough to confide in a peer who is helping them as they focus on improving specific mathematical skills.

Studies show that teachers of mathematics, science, social studies, physical education, and other subjects can use the principles governing this investigation to

improve specific skills (Topping, 2003, Gabriele and Montecinos, 2001, Arreaga-Mayer, 1998, d'Arripe-Longueville, 2002).The element of time and the characteristic of determination are the keys necessary for successfully implementing a tutoring program. Teacher time spent planning, tutoring, and conferencing are all indicators of teacher dedication, but more can be done to sharpen students' skills and increase levels of proficiency. Examining peer tutoring programs extensively may provide the link from student attitudes to increased achievement.

Peer tutoring has been shown to improve student achievement in a number of educational settings. Instructional challenges never before encountered are upon us. The population ofstudents who now enter our schools is rapidly changing from those taught in past generations. Increased mobility cause concerns to naturally turn toward accommodating school populations which are becoming more culturally and linguistically diverse (Maheady & Mallette, 1991). In our transient society, families are constantly relocating to new school zones (Sanderson & Hartman, 2003). Consequently, students' grades are adversely affected by the inconsistent instruction provided for them. Home environments are changing and necessary support may be lacking as single-parent homes are more prevalent and problematic. It is not anticipated that peer tutoring will solve all of the problems that exist in education within today's society, however, it is an intervention that has been proven effective in helping students and teachers.

Summary

Many complex problems exist in today's educational arena. Class sizes are getting larger, there is a critical shortage of qualified mathematics teachers, and students often need a great deal of extra assistance and practice in mathematics which teachers cannot

adequately provide on an ongoing, daily basis. This study was conducted in hopes of identifying peer tutoring as another viable solution for this common problem. More extensive research should be done in this critical area. A longitudinal study involving parents, teachers, tutors, and tutees would provide more data that could be analyzed in an attempt to determine the connection between increased achievement and positive attitudes. With this knowledge, we could help our student population improve their academic skills for increased future success in life. We want our students to be motivated, self-directed, high achievers. It is a desire for excellence that has inspired this research and should inspire further studies involving peer tutoring in all academic areas.

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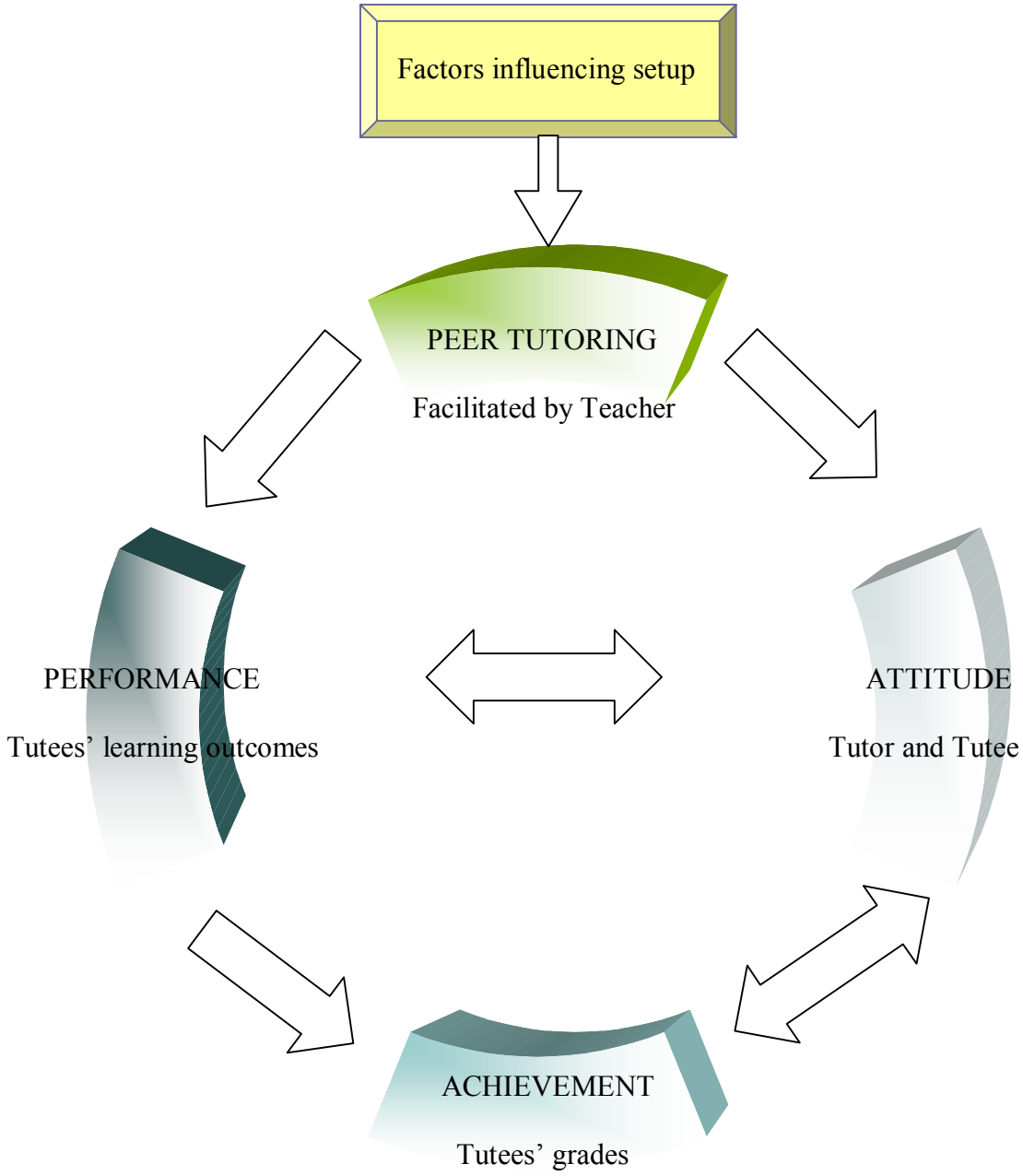
APPENDIX A

TUTORING RELATIONAL CYCLE

APPENDIX A: TUTORING RELATIONAL CYCLE



In this framework tutoring leads to three dimensions of learning outcomes. Performance and attitude are directly affected by tutoring and both of these factors lead to achievement. Performance and attitude also have an effect on one another as do achievement and attitude.

APPENDIX B

MATHEMATICAL DISPOSITION SURVEY

APPENDIX B: MATHEMATICAL DISPOSITION SURVEY

MDS Survey questions

1 – Strongly Agree, 2 – Agree, 3 – Neutral, 4 – Disagree, 5 – Strongly Disagree

1. All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems.
2. Problem solving in mathematics basically means matching problems with facts or equations and then substituting values to get a number.
3. I spend a lot of time figuring out and understanding at least some of the derivations or proofs given either in a lecture or in a text.
4. I often read a mathematics textbook in detail and work through many of the examples given there.
5. Typically, I do not understand mathematical equations and definitions in an intuitive sense; they just have to be taken as givens.
6. The best way for me to learn mathematics is by solving many problems rather than by carefully analyzing a few in detail and trying to understand the underlying concepts.
7. I see a relationship between what I learn in mathematics and what I experience in the real world.
8. A good understanding of mathematics is necessary for most students to be able to achieve their career goals. Simply getting good grades is not enough.
9. Knowledge in mathematics consists of many pieces of information each of which applies primarily to a specific situation.
10. Learning mathematics requires that I substantially rethink, restructure, and reorganize the information that I am given in a class and/or in the text.
11. Understanding mathematics is primarily achieved by memorizing facts and procedures. Insight or creativity has little to do with it.
12. Learning mathematics is nothing more than acquiring knowledge that is specifically located in the equations, definitions, and theorems given in class and/or in the textbook.
13. In doing a math problem, if my calculation gives a result that differs significantly from what I expect, I'd have to trust the calculation.
14. The derivations or proofs encountered in a mathematics course or text have little to do with solving problems or with the skills that are needed to succeed in a course.
15. Only very few specially qualified people are capable of really understanding mathematics.
16. To understand mathematics, I sometimes think about situations in my everyday life and relate them to the topic being analyzed.
17. The most crucial thing in solving a math problem is finding the right equation to use.
18. If I don't remember a particular equation needed for a problem in an exam there's nothing much I can do (legally!) to come up with it.
19. If I came up with two different approaches to a problem and they gave different answers, I would not worry about it; I would just choose the answer that seemed most reasonable. (Assume the answer is not in the back of the book.)
20. Mathematics is related to the real world and it sometimes helps to think about the connection, but it is rarely essential for succeeding in a mathematics course.

21. The results of an exam don't give any useful guidance to an improved understanding of the course material. All the learning associated with an exam is in the studying that occurs before it takes place.
22. The main purpose of studying mathematics is learning how to solve math problems.
23. It is possible to pass most mathematics courses (get a "C" or better) without understanding the underlying concepts very well.
24. Learning mathematics helps me understand situations in my everyday life.
25. When I solve most mathematics problems, I explicitly think about the concepts that underlie the problem.
26. Understanding mathematics basically means being able to recall something you've read or been shown.
27. Spending a lot of time (half an hour or more) working on a problem is a waste of time. If I don't make progress quickly, I'd be better off asking someone who knows more than I do.
28. A significant problem in mathematics courses is being able to memorize all the required information.
29. One of the main results of studying mathematics is to learn how to reason logically.
30. I use the mistakes I make in solving mathematics problems as clues to what I need to do to understand the material better.
31. To be able to use an equation in a problem (particularly in a problem that I haven’t seen before), I need to know more than what each term in the equation represents.

APPENDIX C

RESULTS FROM ONE WORD QUESTION

APPENDIX C: RESULTS FROM ONE WORD QUESTION

RESULTS FROM "ONE-WORD" QUESTION

On the first day of class of spring term 2004 students in the classes listed below (course titles are given in the second table) were asked to respond to the question, "If you had to describe your feelings about math with one word, what word would you use?". A total of 444 students gave 160 different words to describe their feelings; the most frequent are shown in the first table. The complete list of words is given on the next page.

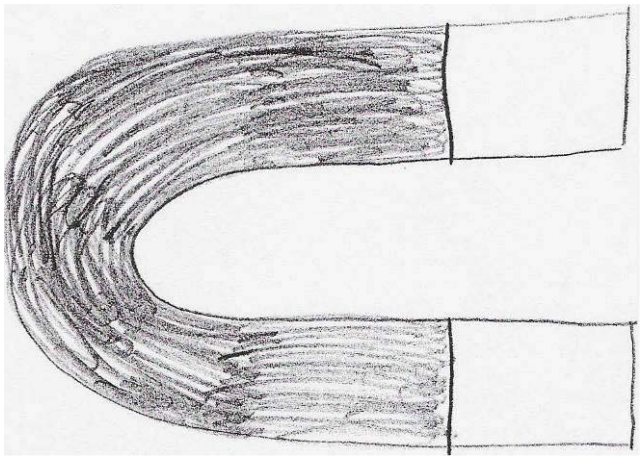
							MDO							
Word	Frequency	Mean	Median	Range	Female	Male	103	107	108	111	122	126	127	151
Frustrating (8.7%)	39	2.08	2.04	1.63	24	14	12	4	6	5	1	8	1	2
Interesting (6.1%)	27	1.73	1.81	1.07	19	8	6	5	4	2	1	8	1	
Challenging (5.4%)	24	1.79	1.74	1.3	15	8	4	3	2	3	3	8	1	
Confus –ing, –ed, –ion	23	2.12	2.15	1.15	15	8	5	1		7	1	8	1	
Difficult (4.5%)	20	2.17	2.23	1.33										
Logic –al, -ally (3.6%)	16	1.73	1.63	1.11	7	9	4	2	1	2		5		1
Hard (2.9%)	13	2.24	2.22	0.92	10	3	4	3		2		4		
Necessary (2.5%)	11	1.68	1.67	0.85			3			1	1	4	2	
Useful (2.5%)	11	1.96	1.96	1.00	6	5		2	2	2		3	2	
Boring	8	2.13	2.19	1.11	6	2	1	1		3	2	1		
Complicated	8	1.97	2.04	1.30	6	2	2	2		1		2		2
Neutral	8	1.93	1.93	0.60	5	3	1	3		2		1	1	
Dislike	7	2.18	2.00	1.14	5	1	2	1	1	1		2		
Intriguing	7	1.76	1.52	1.3	4	3	1	1		1		3	1	
Complex	6	1.75	1.78	0.56	4	3	2	1		1	1	1	1	
Hate	5	2.33	2.32	0.60	5	0	3	1			1			
Anxiety	4	1.96	1.93	1.18	4		1	1		1		1		
Enjoyment	4	1.50	1.58	0.50	2	2		2					2	
Essential	4	1.64	1.63	0.70	1	2		2					2	
Important	4	1.72	1.71	0.41	1	2	1				1	2		
Indifferent	4	2.23	2.21	0.89	3	1		1		2		1		
Intimidating	4	2.17	2.23	0.66	1	3	2	1		1				
Stressful	4	2.33	2.43	0.48	3	1	1			1		2		
Work	4	2.03	1.97	0.63	3	1				2		2		

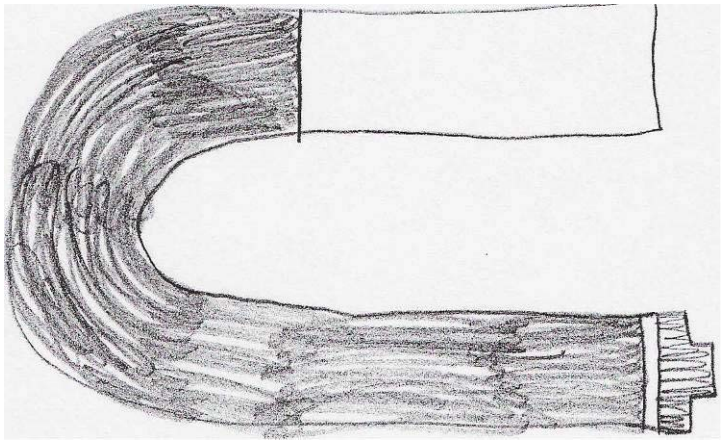
Course Number	Course Name	# sections	# of students
103	Elementary Algebraic Models in Our World	4	90 (20%)
107	Elementary Descriptive Geometry	2	61 (14%)
108	Elem. Numerical Math From A Modern Perspective	1	29 (7%)
111	College Algebra	2	65 (15%)
122	Pre-Calculus	1	23 (5%)
126	Calculus I	5	136 (31%)
127	Calculus II	1	26 (6%)
151	Calculus for the Life Sciences	1	14 (3%)
	Total	**17**	**444**
	Female (58%) / Male (39%)	**259/174 (11 unknown)**	

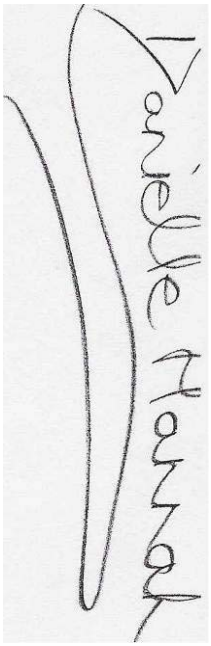
APPENDIX D

PIAGET'S STAGES OF DEVELOPMENT - DANIELLE

APPENDIX 4: PIAGET'S STAGES OF DEVELOPMENT - DANIELLE







APPENDIX E

PIAGET'S STAGES OF DEVELOPMENT - MILES

APPENDIX E: PIAGET'S STAGES OF DEVELOPMENT - MILES

APPENDIX F

ANOVA TABLES

APPENDIX F: ANOVA TABLES

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.
PRE_POST	ACH	Sphericity Assumed	65.761	1	65.761	35.616	.000
		Greenhouse-Geisser	65.761	1.000	65.761	35.616	.000
		Huynh-Feldt	65.761	1.000	65.761	35.616	.000
		Lower-bound	65.761	1.000	65.761	35.616	.000
	ATT	Sphericity Assumed	9.541E-02	1	9.541E-02	1.606	.208
		Greenhouse-Geisser	9.541E-02	1.000	9.541E-02	1.606	.208
		Huynh-Feldt	9.541E-02	1.000	9.541E-02	1.606	.208
		Lower-bound	9.541E-02	1.000	9.541E-02	1.606	.208
PRE_POST * GROUP	ACH	Sphericity Assumed	33.065	1	33.065	17.908	.000
		Greenhouse-Geisser	33.065	1.000	33.065	17.908	.000
		Huynh-Feldt	33.065	1.000	33.065	17.908	.000
		Lower-bound	33.065	1.000	33.065	17.908	.000
	ATT	Sphericity Assumed	.191	1	.191	3.216	.076
		Greenhouse-Geisser	.191	1.000	.191	3.216	.076
		Huynh-Feldt	.191	1.000	.191	3.216	.076
		Lower-bound	.191	1.000	.191	3.216	.076
Error(PRE_POST)	ACH	Sphericity Assumed	166.174	90	1.846		
		Greenhouse-Geisser	166.174	90.000	1.846		
		Huynh-Feldt	166.174	90.000	1.846		
		Lower-bound	166.174	90.000	1.846		
	ATT	Sphericity Assumed	5.348	90	5.942E-02		
		Greenhouse-Geisser	5.348	90.000	5.942E-02		
		Huynh-Feldt	5.348	90.000	5.942E-02		
		Lower-bound	5.348	90.000	5.942E-02		

APPENDIX G

STUDENT GRADES

Student Grades.xls