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2010

ABSTRACT

The Impact of Use of Mathematics Manipulatives on Attitudes
Toward Mathematics Success Among
Students in a Multigrade Classroom

by

Betty F. Nugent

M.A., Andrews University, 1986
B.S., Southern Adventist University, 1979

Doctoral Study Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Education
Teacher Leadership

Walden University
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ABSTRACT

Math manipulatives are designed to help students visualize and maneuver math concepts. Many studies have been conducted using manipulatives in a single-grade classroom. The purpose of this quantitative study was to determine the impact of a structured manipulatives program, which had been aligned with standards and all textbooks, on students' attitudes toward mathematics success in a multigrade classroom. Most teachers are not trained to align curriculum, coordinate activities, and manage children at the various grade levels in a multigrade classroom. Brain based learning proponents argue that only information of interest to the brain will be recognized as important. Learner centered theorists suggest that maximum learning can only take place when the classroom environment is cognizant to the needs of the child. This quasi-experimental, quantitative study used a single-group interrupted time-series design. A survey measured student attitudes towards math. An observational checklist measured time spent completing math assignments. The related-samples *t* statistic analysis indicated significant improvement in student attitudes toward math success, confidence, anxiety, and usefulness of math. The related-samples *t* statistic analysis also indicated significant improvement of time students spent completing math assignments while using structured manipulatives. A recommendation for teachers of multigrade classrooms is to use structured math manipulatives to enhance student attitudes towards math. Implications for social change include improved student attitudes towards mathematics, which may lead to mathematics success and mathematics achievement.

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DEDICATION

This work is dedicated to my loving Savior Jesus Christ, to whom I owe all and return all, for the uplifting of the kingdom of God. This work is also dedicated to every student who has ever entered my classroom for the purpose of gaining the light of knowledge.

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CHAPTER 1:

INTRODUCTION TO THE STUDY

Inspiration for Inquiry

Kindergarten was difficult for Adrian (a pseudonym). His motor skills were low, his speech slurred, and he was emotionally unstable. Learning numbers and counting seemed impossible for him. School was such a challenge that Adrian cried at least three days a week, several times a day. At the beginning of fifth grade, Adrian continued to struggle in mathematics. When told that he would learn algebra readiness skills with manipulatives, Adrian expressed joy because he saw them as toys. Near the end of the fifth grade the teacher wrote the equation, $3x + 4 = 2x + 10$, on the board. Within seconds of rearranging the manipulatives on his desk, Adrian energetically waved his hand with the answer. Remembering his past, the teacher smiled as she realized that Adrian had traveled from, “I can’t” to “I did it!”

Adrian attends a small school in which all of the classrooms are multigrade. Most subjects in all of the classrooms are taught synchronously, with the teacher teaching the same subject to all grades in the classroom during the same block of time. Because the classrooms are multigrade and not multiage, students are assigned textbooks designed for their grade level in most subjects. For example, if Grades 5 through 8 are in the same classroom the teacher teaches from the fifth-, sixth-, seventh-, and eighth- grade mathematics textbooks during the 55 mathematics block of time each day. The number of grades in the multigrade classroom depends upon enrollment of the school each year. This method of teaching consumes valuable planning and teaching time in order to complete required standards during the school year. There is little time left to incorporate creative activities, such as manipulatives, into the teaching time.

Adrian is currently in the upper grades classroom for Grades 7, 8, and 9 at his school. His teacher has aligned the mathematics manipulatives with both the seventh-grade and eighth-grade textbooks and standards for the school year. This method allows her to teach the students of each grade each day using their own mathematics textbook while she uses the same manipulatives activities to enhance the instruction of both grades.

Using a variety of manipulatives that have been aligned with the classroom textbook and state standards has the potential to prepare students for Algebra I. Providing a structured environment in which students can manipulate math as it is learned from the regular textbook may lead to better attitudes towards math, and may help them anticipate their work in high school mathematics and beyond. Williams and Williams (2010) found a statistically significant relationship between self-efficacy and mathematics performance in 26 of 30 nations compared. Hagerty, Smith, and Goodwin (2010) found similar results; namely, that students who believe that they can succeed in mathematics will spend more time doing math and are more likely to enroll in advanced mathematics courses.

Society expects that students who graduate from high school will be prepared to compete on a global plane. Unfortunately, students in the United States continue to lag behind their international counterparts in math (Mullis, Martin, Gonzalez, & Chrotowski, 2004). Singapore serves as an appropriate comparison to the United States. In Singapore, each element of the mathematics system is aligned. Students in Singapore continue to experience mathematics success, as reflected on three successive Trends in International Mathematics and Science Studies (Leinwand & Ginsburg, 2007). When the mathematics program is not aligned, too many stories like Adrian's are repeated, but without a successful conclusion. Fortunately, there are school systems in the United States that have sought out and implemented creative programs to help bridge the math learning gap. Various math manipulatives are included in many of these programs.

International Math Results

During the initial reviews of the Third International Mathematics and Science Study Silver (1998) concluded that at U.S. students in the 7th, 8th, 11th, and 12th grades did not perform as well as their counterparts in the rest of the world.. At the time, twelfth graders in advanced math courses in the U.S. performed significantly lower than students in most other developed nations. Performance of U.S. students was nearly equivalent to international averages in areas related to algebra, fractions, and probability; however, it was below average in geometry, measurement, and proportionality. When the Trends in Mathematics and Science Study (TIMSS) was conducted in 2007 (National Center for Education Statistics 2009), U.S. students showed slight improvement over previous years. Table 1 displays the means of some of the nations whose students participated in the TIMSS each of the four years listed.

Table 1

Means of Eighth-graders who Outscored U. S. Students

Country of students	1995	1999	2003	2007
Singapore	609	604	605	593
Rep of Korea	581	587	589	597
Hong Kong	569	582	586	572
Japan	581	579	570	570
Hungary	527	532	529	517
USA	492	502	504	508

Note. International Association for the Evaluation of Educational Achievement (IEA), Trends in International Mathematics and Science Study (TIMSS), 2007. Public Domain.

As can be seen from Table 1, the mean of eighth grade math students in the United States increased from previous years. Although U.S. eighth grade math students continued to score above the TIMSS scale average of 500, they continued to be outscored by their counterparts in other countries (National Center for Education Statistics, 2009). A number of additional countries intermittently outscored the U.S., though not consistently over the years.

When discussing the TIMSS-95, Silver (1998) concluded that unless deliberate speed is used to improve seventh- and eighth-grade math education, U.S. students would not be prepared for the challenges that await them as adults. Silver (1998) did not condemn the U.S. mathematics standards but suggested that creative teaching replace repetition of standards found in elementary and middle school mathematics textbooks. Silver's recommendations encouraged teachers to determine and creatively teach the foundations necessary for grasping advanced high school math concepts. Other researchers have underscored the need for a change in American math classrooms: In a comparison study between the U.S. mathematics system and that of Singapore, Ginsburg, Leinwand, Anstrom, and Pollock (2005) concluded that too much repetition still exists in the U.S. system. Not only are the standards repeated, but also U.S. textbooks include redundancy and reteaching of objectives and topics for as much as three successive grades (Ginsburg et al., 2005). Research performed by the International Center for Leadership in Education (2006) under the leadership of Bill Daggett indicated that if the trend continued, students in the United States would not be able to compete with their Asian counterparts in the job market. The International Center for Leadership in Education (2006) suggested that all school districts provide students with a rigorous curriculum, which is relevant to the real world. In other words, schools need to make direct connections and application between content knowledge and job-related skills they are acquiring in classes. Research suggests that more math content in the classroom does not necessarily equate with better math proficiency. Indeed, North Carolina and Texas, states that teach the fewest math topics yearly in the U.S., have been recognized as the most successful, according to the National Assessment of Educational Progress (Leinwand & Ginsburg, 2007). For many years, the National Council of Teachers of Mathematics (NCTM) has promoted the weaving of communications, problem solving, reasoning, and connections in K-12 mathematics education. The recent streamlining of standards by NCTM (2008) is a rigorous attempt to encourage mathematics educators and administrators to take a closer look at their curricula. The state of Florida has followed the example set by the NCTM.

I am a mathematics educator in the state of Florida, working in a parochial school system, which uses the NCTM and Florida Sunshine State Standards. Adoption of the 2007 Florida Sunshine State Standards (2008) by the Florida Board of Education has reduced the yearly repetition of standards, as recommended by educators who assessed the last four TIMSS (Ginsburg et al., 2005; Leinwand & Ginsburg, 2007; Mullis et al., 2004; Silver, 1998). The revised standards in Florida clearly contrast new benchmarks with ideas that are being reinforced from a previous grade. In the same vein, I served on a committee, which assisted the Southern Union Conference (SUC) in preparing less repetitive math standards that follow the NCTM framework (Adventist Edge, 2008). These new standards are aligned with the growing trend suggested above; in which teachers implement lessons that require students to use and apply advanced problem solving and conceptual skills while reducing repetition.

School districts in the U.S. are to be applauded for improvement of their math students. Since 1995, scores of eighth grade math students in the U.S. have increased by 16 points on international tests (Harmon et al., 2008; National Center for Education Statistics, 2009). Even though this reflects improvement, the continued gap between U.S. students and their global counterparts indicates that change is still needed in mathematics classrooms in the United States. The narrowing, but prevalent, gap suggests that perhaps school districts have made some changes, but students are still not thoroughly grasping the material. It is time for mathematics educators to either think and teach differently, or expand what has worked into all educational settings.

Effective Mathematics *Initiatives*

Ham and Walker (1999) examined the impact of the Equity 2000 initiative whose goal was to enable students from underprivileged homes in the city of Milwaukee to be successful in Algebra and Geometry and, thereby, be better prepared for college and life. Regrettably, these researchers found many middle school mathematics teachers to be inadequately trained to teach algebra and algebra readiness skills. Among the various techniques implemented by Milwaukee Public Schools to counter this deficiency was the Connected Mathematics Project. This mathematics curriculum, for Grades 6 through 8, embeds algebraic concepts throughout the year. Additionally, intensive training for middle school mathematics teachers is provided through summer institutes and ongoing in-service during the school year in Milwaukee. Teachers who participated in the institutes commented on the content rich manipulative activities that were ready to use in the classroom. The Milwaukee Public School educators realized the necessity of increasing public consciousness towards the impact of adults' expectations on student's dispositions and their academic performance. In order to improve student attitudes and academic performance, the Equity 2000 initiative trained teachers in the use of an assortment of hands on activities. Training sessions also included the use of calculators and a variety of manipulatives. The initiative also held special sessions for middle school mathematics teachers to increase their content area knowledge and teaching strategies.

The Milwaukee Public Schools' District Report Card (2010) indicates that eighth grade mathematics students in Milwaukee have continued to improve since 1999. During the 2008-09 school year, approximately 75% of all schools reached mathematics proficiency. During that year, 48% of eighth grade students were math proficient. Although these students were not where the district wanted them to be, this was a significant improvement over the 11% proficiency in the year 2000.

As with Milwaukee, other municipalities and states have considered the issue of middle school mathematics. For example, the state of Texas received funds from the No Child Left Behind Act of 2001, which allowed for implementation of programs to improve middle school mathematics. The Southeast Texas Education Service Center Region VI (Texas Education Service Education Center Region VI, 2006) identified Algebra as "the gatekeeper course for college preparatory courses" (p. 1). The state of Texas launched the Algebra I initiative to guarantee that every student in Texas masters this course, necessary for success in higher mathematics and college. A student who is successful in Algebra will have career options that would have otherwise not been available. The Southeast Texas initiative, like to the Milwaukee program, taught teachers how to teach with manipulatives and other nontraditional strategies. Since full implementation of these strategies, mathematics scores on the Texas Assessment of Knowledge and Skills have continued to climb (Texas Education Agency, 2010). In the spring of 2010, 80% of eighth grade students met the mathematics standard. This is an improvement over the spring of 2005 scores, which revealed that 61% of Texas eighth graders met the mathematics standard.

The Milwaukee and Southeast Texas teachers determined that embedding algebraic concepts in middle school mathematics was a key to success in high school mathematics (Ham & Walker, 1999; Texas Education Service Center Region VI, 2006). Another concern in Texas and Milwaukee was the applicability of algebra skills beyond the course. Ongoing workshops during the school year aided the teachers in making algebra practical in the classroom. Clearly, these two school districts realized that once middle school teachers become comfortable teaching mathematics with manipulatives, mathematics attitudes and achievement improve. Yet few districts are aware of the significance of mathematics manipulatives in middle school mathematics (2006), and few have the resources to provide appropriate teacher training and teaching materials. Additionally, there is no indication that any of the programs mentioned above involve multigrade classrooms.

Multigrade teachers often find affordable professional development programs that present creative teaching strategies that have been developed for single-grade classrooms, but they are unable to adapt them to the schedules of their own classrooms. After several failed attempts at implementing a reading program designed for single-grade classrooms into her own multigrade classroom, Mayo (2003) implored fellow multigrade teachers to do their utmost to ensure that students have the tools they need to fulfill their potential (p. 2). Unable to find a creative science program that would enhance her multigrade classroom and accommodate its extensive range of ages, Maria Carlton (as cited in Campbell & Burton, 1991) developed her own. It required tenacious organization and considerable time to design, but it revitalized her entire classroom of four grades. Multigrade teachers like Mayo and Carlton could benefit from creative programs that either do not yet exist, or have not been publicized and validated. Multigrade teachers need programs that are designed with sensitivity towards the time and organizational restrictions of their classrooms. A more detailed discussion of mathematics manipulatives and multigrade classrooms can be found in chapter 2.

Problem Statement

There is a problem of performance in the seventh-and eighth-grade mathematics classroom of a small parochial school in the southern United States. That problem specifically is that total mathematics scores on the Iowa Test of Basic Skills (ITBS), for both seventh- and eighth- grade students in the classroom, and have consistently fallen below the 45th percentile range for three consecutive years (ITBS, 2008; Yu, 2008). Nearly all of the classrooms of the larger parochial school system that this school is facilitated with are multigrade as well, yet as a group, they have consistently risen above the 50th percentile range on the ITBS for the same period (Cognitive Genesis Report, 2009). To address this problem the school recently hired a fully certified mathematics teacher for Grades 6-8 and obtained funds to hire a math resource teacher for grades K-6. Unfortunately, the ITBS scores have not increased. This problem affects mathematics students preparing for high school in two major respects. First, performance in the mathematics classroom and on the ITBS contributes to placement in high school mathematics courses. Second, mastery of algebra readiness skills has been shown to contribute to success in high school mathematics courses (Ham & Walker, 1999; Texas Education Service Center Region VI, 2006).

All of the classrooms of the school of the current study are multigrade, and there is justifiable concern over low ITBS math scores in all of the them. Many possible factors contribute to poor math performance by students. I will discuss problems specific to mathematics learning in multigrade classrooms in chapter 2. Here, however, are some explanations for poor mathematics performance in general that I have gleaned from the current research.

First, low arithmetic performance in early grades convinces students that mathematics is difficult, causing them to continue to do poorly in math. Crosnoe et al. (2010) found that students who are less prepared for math in early years seldom catch up as they progress in school.

A second cause may be that parents may not know how to help their children excel in mathematics. In every academic area, achievement is driven by family involvement (Goldman & Booker, 2009). Parents are more likely to help children with math as their own confidence increases and the school “promotes respect for the family’s unique mathematical contexts” (2009, p. 385).

A third reason for low performance could be that teachers of multigrade classrooms do not have time to organize math instruction in such a way as to teach the standards in a manner that allows each grade in the classroom to grasp the concepts. According to Vincent (1999) and Merckx (2010), addressing the broad range of student needs in a multigrade classroom requires considerable extra time and work in planning and preparation.

A fourth reason for low student math performance may be that elementary students in the U.S. are usually taught by nonmath teachers. Elementary certification generally requires little mathematics preparation (National Council of Teachers of Mathematics, 1989). As with the teaching of reading, effective preparation of mathematics teachers is an issue of paramount importance to educators attempting to enhance student learning (Morris, Hiebert, & Spitzer, 2009). Unlike Asian teachers, K-5 elementary teachers in the U.S. are expected to master and teach all subjects (Newton, 2007). Every classroom in the school of the current study is multigrade classrooms, and all of the teachers teach all subjects. A deeper discussion of multigrade classrooms can be found in chapter 2.

A fifth possible cause of students failing to learn math is that they sometimes have difficulty grasping abstract mathematical concepts (National Research Council, 2002). For these students, the use of manipulative has been successful (Flores, 2010).

A sixth, and possibly the most important, cause of poor mathematics performance might be that students with low self-efficacy in math may become less motivated and will, consequently, perform poorly (Buehl & Alexander, 2005). Some students even view math as a form of torture (Briggs, 2007). This feeling prevents students from appreciating the joys of math. Rosemary Karr (2007), community college professor of the year for 2007, suggested that this negative feeling towards math results from anxiety. According to Newton (2007), this type of anxiety causes people to resign themselves to the fact that, "I just can't do math." This statement, she claims, has become acceptable in the U.S. and results in poor math performance because it prevents students from trying to do math (Newton, 2007). According to the *Curriculum and Evaluation Standards for School Mathematics* of the National Council of Teachers of Mathematics (1989), "beliefs exert a powerful influence on students' evaluation of their own ability, on their willingness to engage in mathematical tasks, and on their ultimate mathematics disposition" (p. 233).

This study contributes to the body of knowledge needed to address the problem of middle school students' failure to learn and enjoy mathematics by determining whether the attitudes of seventh- and eighth-grade students, taught synchronously in a multigrade classroom, are affected by the implementation of a structured mathematics program. The structured program is one in which the common math standards found in both of the seventh- and eighth-grade textbooks have been aligned with appropriate manipulatives so that they were taught on the same days and at the same math time for one quarter. The variables examined are student attitudes while not using manipulatives, and student attitudes while using manipulatives.

Purpose Statement

The purpose of this quasi-experimental study was to examine the attitudes of seventh- and eighth- grade students in a multigrade mathematics classroom under two conditions: learning mathematics with the textbook only and learning mathematics with the textbook plus manipulatives that were correlated with textbook lessons. Various types of mathematics manipulatives are commonly used in multigrade, or “combination,” classrooms; however, they are seldom used in a structured approach to teach math. In the structured program that this study investigates, manipulatives were correlated with mathematics state standards and grade-specific mathematics textbooks used in a multigrade classroom during the third nine-week period of the 2009-2010 school year. The program also includes the use of worksheets or real-world activities for each manipulative as well as printed instruction on how to use them and a timeframe for their use. As teacher-researcher, I kept the manipulatives in a large cabinet in the classroom with a separate bin for each set and placed the assignment for each set of manipulatives, instructions, and correlated standards in a binder. Designation markers were placed within the teacher’s edition of the both the seventh- and eighth- grade mathematics textbooks to indicate the availability of a manipulative activity for a specified objective.

Nature of Study

The purpose of this quasi-experimental study was to examine the impact of a structured mathematics manipulatives program on the attitudes of seventh- and eighth-grade students in a multigrade classroom. This quasi-experimental study used a single-group interrupted time-series design. I chose the quasi-experimental design over the truer experimental design because the participants consisted of one intact group (Creswell, 2003) which was available to me.

The sample population for this study consisted of all seventh- and eighth-grade mathematics students in a church affiliated K-8 school in the southern United States, one of the 203 schools located in the division described above In an attempt to understand the attitudes of multigrade students using mathematics manipulatives, data collection included results of the Mathematics Attitudes Survey (found in Appendix A) and classroom observations using the Classroom Observation Checklist (found in the Appendix B). Mulhern and Rae used factor analysis used to establish validity and reliability of the constructs of the Fenneman-Sherman Mathematics Attitudes Scales Short Form (FSMAS-SF). Excerpts of the FSMAS-SF were used to prepare the Mathematics Attitudes Survey (MAS). Face validity and inter-observer reliability exists for the data collection using the Classroom Observation Checklist. A more detailed explanation of the reliability and validity of the data collection instruments are found in chapter 3.

Research Question and Hypotheses

The following research question guides this study: What impact will a structured mathematics manipulatives program have on mathematics attitudes of seventh- and eighth-grade students who are taught synchronously in a multigrade classroom? The related hypotheses are below.

Ho1: Mathematics manipulatives will have no impact on student attitudes towards mathematics success in a multigrade mathematics classroom.

H_a1: Mathematics manipulatives will have a positive impact on student attitudes towards mathematics success in a multigrade mathematics classroom.

H_o2: Mathematics manipulatives will have no impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

H_a2: Mathematics manipulatives will have a positive impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

H_o3: Mathematics manipulatives will have no impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

H_a3: Mathematics manipulatives will have a positive impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

$H_o 4$: Using mathematics manipulatives will have no impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

H_a4: Using mathematics manipulatives will have a positive impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

$H_o 5$: Using mathematics manipulatives will neither increase nor decrease the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

H_a5: Using mathematics manipulatives will increase the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

The independent variables that applied to the group are teaching mathematics with the textbook only and teaching mathematics with the textbook along with structured manipulatives. The dependent variables measured by a mathematics attitudes survey were attitudes towards success in mathematics, mathematics-related affect (based on the combination of confidence in learning mathematics and mathematics anxiety while learning mathematics), and usefulness of mathematics. An observation checklist was used to measure the dependent variable of time on-task during mathematics instruction and practice. Specific details of this question, related hypotheses, and the form of analysis, will be addressed in chapter 3.

Theoretical Framework

Learning theories are foundational ideas, which explain how students learn and how teachers teach. Two related learning theories, brain-based learning and learner-centered principles, provided the framework of this study and are discussed below.

Brain-based Learning

Brain based education involves the active engagement of purposeful strategies that are based on principles, which are derived from neuroscience (Jensen, 2008). When learning follows the natural way that the brain is designed to learn brain based education is taking place. The brain itself is comprised of more than 10 billion neurons, which transport nerve impulses (Doidge, 2007). Nerve impulses are carried to other neurons by the axon, the longest of several tubelike fibers. Dendrites are shorter fibers that are shaped like trees, which receive impulses from other neurons and transmit them into the cell body. Excitatory signals received in abundance cause a neuron to fire or transmit impulses. When the electrical signal reaches the tip of the axon, chemical messages, also called neurotransmitters, are electrically released into the microscopic space between axons and dendrites. The electrical message either excites or inhibits the neuron. When two neurons repeatedly fire simultaneously, the two form a stronger connection. The stronger the connection the more powerful the learning experience (Bogoch, 1986; Doidge, 2007; Merzenich & Jenkins, 1995). The human brain affects the "internal world, and plays a key role in creating perceptions, beliefs, reactions, responses, and behaviors" (Taylor, Brewer, & Nash, 2003, p. 29.) In 1990, Caine and Caine investigated the brain-based approach to education and suggested that a brain-friendly environment "should be able to satisfy the brain's enormous curiosity and hunger for novelty, discovery, and challenge" (p. 67). The Caine Learning Institute (2008) is devoted to digesting brain research so that it is useful for educators. First published in 1989, the 12 principles of Brain Learning reflect biological and psychological aspects of learning that take place in human beings and are summarized below:

1. All learning is physiological.
2. The brain is social.
3. The search for meaning is innate.
4. The search for meaning occurs through patterning.
5. Emotions are critical to patterning.
6. The brain processes parts and wholes simultaneously.
7. Learning involves both focused attention and peripheral perception.
8. Learning always involves conscious and unconscious processes.
9. The two memory organizers are autobiographical and rote.
10. Learning is developmental.
11. Complex learning is enhanced by challenge and inhibited by threat.

12. Each brain is uniquely organized.

Especially significant to learning mathematics concepts are principles 4, 6, and 11. Principle 4 suggests that patterns are needed for the brain to acquire the meaning of a concept. While patterns are abundant in mathematics, presentations by textbook authors and teachers do not always render successful comprehension and application of them. Principle six suggests that problems or concepts need to be introduced holistically, or as components within an overall pattern of interrelation, if they are to be understood. Principle eleven addresses the balance of challenge and threat. While the complex brain invites challenge, an environment void of physical and emotional threat must exist for mastery to take place. The brain functions best in a challenging environment that utilizes and applies prior learning.

Gulpinar (2005) summarized what has become the Principles of Brain Learning into three fundamental elements for effective teaching:

1. Relaxed Alertness—creating the optimal emotional and social climate (challenging, but non-threatening, and confirmative environment with complex social interactions) for learning.
2. Orchestrated Immersion in Complex Experience—creating optimal opportunities for learning by providing learners rich, complex, and realistic experiences; giving learners time and opportunity to make sense of their experiences by reflecting, finding, and constructing meaningful connections in how things relate, while at the same time, presenting efficient tutorial.

3. Active Processing of Experience—creating optimal ways to consolidate learning, i.e., continuous active processing of ongoing changes and experiences to construct, elaborate and consolidate "mental models/patternings" (p. 302).

Gulpinar (2005) suggested that constructivist teaching models such as problem-based learning, experiential learning, or cooperative learning are the most brain-friendly. One example of such a teaching model is the 4MAT System, which can also be adapted for use outside the field of education. The 4MAT System is a brain-friendly program, which provides a framework for reaching the four different learning styles (McCarthy & Morris, 2002). As teachers instruct around the 4MAT wheel, each learning style receives emphasis. The Office of Education of the North American Division (NAD), conducts evaluation of the school investigated in this study, and has encouraged all of its teachers to be trained in the 4MAT System framework. The NAD has advised educators that 4MAT provides a foundation for understanding the core elements of learning, while illustrating the natural cycle of learning and advancing the potency of the four major learning styles (Journey to Excellence Journey to Excellence, 2008). Based on research on the two hemispheres of the brain, the learning styles can best be summarized by the questions they ask: Type 1, why; Type 2, what; Type 3; how; and Type 4, what if (McCarthy & Morris, 2002). While a teacher may, herself, learn best as a Type 4 who asks "What if?", she must bear in mind that various types of students are in the classroom. According to Sousa (2006), "Because teachers tend to teach the way they learn, they need to know as much about their learning style[sic] as possible" (p. 171). In addition to helping the teachers understand their own learning styles, knowledge of the four major learning styles helps them to better understand the various ways that their students learn and tailor their instruction accordingly.

Konecki and Schiller (2002) and Dwyer (2003) described the process carried out by the brain when new sense data are received. As the sensory receptors in the brain receive new stimuli, the thalamus processes the information and sends it to the amygdala. The amygdala is a key part of the emotional brain, which, among other functions, has the job of determining if new information is a threat to survival. If new information conforms to a pattern associated with threats to survival, the amygdala notifies the body processes of the danger and the brain shifts into fight or flight mode (Kaufeldt, 2005, p.2) and learning is impaired. In order to maximize learning, new information must be presented in an environment that, while perhaps challenging to students, enables them to actively participate without fear of rejection or intimidation (Dwyer, 2002, p. 266).

Researchers such as Smilkstein (1990-91) and Hannaford (1995) explained why new information must be challenging and build on prior learning. Within the brain, dendrites, which are fibers that extend laterally from nerve cells, or neurons. As dendrites grow, they communicate with dendrites originating from other neurons, forming a complex network of millions of neurons. Smilkstein (1990-91) suggested that expansion of neuronal networks will only occur when the learner actively engages new material by "internalizing it, increasing fluency, and, from the start, critically and creatively applying it through trial-and-error activities" (p. 14).

When comparing research on brain-based learning, multiple intelligences, and emotional intelligence, Dwyer (2002) found that only information that interests a learner will trigger the kind of brain activity that occurs when we recognize something as important. If no links with prior knowledge can be found, the brain will reject the information. Kaufeldt (2006) encouraged educators to provide an environment, that endows children with opportunities to expand and enrich their sensory and emotional skills. Sousa (2006) contradicted a popular belief that students can be too left-brained or too right-brained to respond to certain teaching techniques. A brain-sensitive educator creates an environment where the two hemispheres of the brain can work together as an integrated whole, sharing their different stimuli through the corpus callosum. A thick cable of about 200 million nerve fibers, the corpus callosum connects the left and right hemispheres of the brain. It is the job of the corpus callosum to "unify awareness and allow the two hemispheres to share memory and learning" (Sousa, 2006, p. 167). According to Wagmeister and Shifrin (2000, p. 45), "A brain-based program creates a safe, nurturing environment where children expand their knowledge, find patterns, make connections, and take risks." In such an environment, both hemispheres of the brain are actively engaged.

Newman (1998) suggested that the "coordination of variables, classification, combining parts, spatial orientation, reversibility, and conservation, are essential pre-mathematics skills" (p. 8). Another premath skill is number sense, which the Learning Disabilities Association (2005) has linked to future math success. All of these mathematics skills are impaired in students with dyscalculia. Wagmeister and Shifrin (2000) examined the school-wide brain-based instruction at Westmark School in Encino, California. All of the students at this second through twelfth grade school had learning disabilities such as dyslexia, dysgraphia, and dyscalculia. While multisensory programs were used to stimulate the senses and foster positive learning experiences in language arts at Westmark School, hands-on mathematics activities were used for the dyscalculic students. Despite the fact that students with this learning disability, regardless of their age or amount of exposure to the concepts, were unable to retain mathematics facts learned through rote memory, they all experienced mathematics success using hands-on activities (Newman, 1998; Wagmeister & Shifrin, 2000). The successful results of hands-on mathematics activities at the Westmark School ought to provide encouragement for regular education mathematics teachers who are searching for creative learning strategies. These results imply that creative strategies such as mathematics manipulatives will benefit learners in elementary, middle, and even high school.

Several factors must be involved in the process of learning in order for information and concepts to be retained in such a way that students can accurately retrieve them for future use. They include the degree of student focus, how well and how much learning has been rehearsed in class, the degree to which critical attributes of what has been studied have been identified, appropriateness of lessons to students' learning styles, and the extent to which what has been taught is redundant of what has been learned before (Sousa, 2006). When discussing rehearsals for learning, Sousa (2006) emphasized the importance of elaborative rehearsal over rote rehearsal. Rote rehearsal causes information to be stored by the brain only as short-term memory. Elaborative rehearsal, on the other hand, requires the student to observe relationships as they connect the new content with previously learned content. Students use rote rehearsals to memorize multiplication tables and elaborative rehearsals to understand the commutative property of multiplication.

When Smilkstein (1993) discussed rote-memorized-knowledge, declarative-knowing and understanding-knowledge, and procedural-how to-knowledge, she suggested that acquiring declarative knowledge alone does not allow students to apply that knowledge. Procedural knowledge alone fails to provide students with an understanding of what is being done and why. Rote knowledge may be useful for facts used repetitively in mathematics; however, the ability to recall facts is dependent upon "strength of memory trace, physical alertness, nutrition and the quality of the prior learning" (Dwyer, 2002, p. 268). Smilkstein (1993) contended that brain-based and learner-centered strategies encourage the use of manipulatives or some type of hands-on activity. Hands-on activities or lessons using manipulatives allow structured application of rote, declarative, and procedural knowledge.

Fuller (2001) assessed the impact of the implementation of the Partners Advancing the Learning of Math and Science (PALMS) approach on student achievement. The goal of PALMS was to help underprivileged students in Massachusetts become "lifelong, critical thinkers and problem solvers capable of working together" (p.

7). Brain-based learning and learner-centered principles were two of many teaching and learning components used in this approach. The study found that teachers now had more time to adequately identify and assist with specific learning needs of their students. Teachers observed student growth, improved their classroom management, and helped students reach previously untapped potential. Pivotal in the PALMS approach was the use of hands on activities such as manipulatives for mathematics (Fuller, 2001)

According to Sousa (2006), students' ability to apply knowledge to new situations is limited because educators are not doing enough to enhance new learning by making connections. Roberts (2002) encouraged educators to fuse the brain-based research beyond simply learning by doing, using methods such as chunking material in an organized manner, using a bigger picture when presenting information, creating multisensory lesson plans, building relationships with students, and presenting 40% of the class activities in a novel manner.

As suggested by the Caine Learning Institute (2008), the current study physically engaged students in learning math by allowing them to manipulate the concepts. As recommended by Gulpinar (2005), experiential learning took place as students rearranged the manipulatives to complete the written assignments. Manipulating objects allowed students time to reflect and make the strong connections required by neurons to produce a powerful learning experience (Bogoch, 1986; Doidge, 2007; Merzenich & Jenkins, 1995).

Learner-centered Principles

Learner-centered principles focus on what has been found to be psychologically sound practices for individual students in reaching an optimal level of learning (Murphy & Alexander, 2002). In a program based on learner-centered principles, the learner, not the curriculum, textbook, or standards, is the focus of education. Alexander and Murphy (1994) framed the original 12 psychological principles into five general statements. The original 12 principles are nature of the learning process, goals of the learning process, construction of knowledge, higher-order thinking, motivational influences on learning, intrinsic motivation to learn, characteristics of motivation-enhancing learning tasks, developmental constraints and opportunities, social and cultural diversity, social acceptance, self-esteem and learning, individual differences in learning, and cognitive filters (Alexander & Murphy, 1994). Educators should understand and implement the principles as a knowledge foundation, organized to support the Learner-Centered Model (McCombs et al., 1996). The more popular five principles of learner-centered teaching resulted from categorizing the original 12 into associated factors. They are knowledge base, motivation and affect, strategic processing, individual differences, and situation or context. As Murphy and Alexander (2002) suggested, “each student constructs knowledge in accordance with his or her past experiences” (p. 15). The definitions provided by Alexander and Murphy (1994) follow with typical mathematics classroom examples.

1. Knowledge base—"Ones knowledge base serves as the foundation of all future learning by guiding organization and representations" (p. 28). Understanding that "each student constructs knowledge in accordance with his or her past experiences," (Murphy & Alexander, 2002, p. 15) a teacher might use an equation, which contains terms that the students are familiar with as the class opener. This gives the students a comfortable place to start the mathematics day.
2. Motivation—"Motivation or affective factors, such as intrinsic motivation…and personal goals..." (Alexander & Murphy, 1994, p. 33). Applying an unknown term to an equation on the board that serves as the problem of the day motivates students to complete a type of problem that they would, otherwise, feel too afraid to try (Murphy & Alexander, 2002).
3. Strategic processing—"The ability to reflect on and regulate one's thoughts and behaviors…" (Alexander & Murphy, 1994, p. 31). If a teacher uses manipulatives such as tangram puzzles and guides students through the mental process of finding the solution the students will have learned how to "monitor their own mental processing" (Murphy & Alexander, 2002, p. 19) in order to sequentially solve a mathematics problem and complete a tangram puzzle.
4. Individual differences—"Learning….progresses through various common stages of development influenced by both inherited and experiential/environmental factors" (Alexander & Murphy, 1994, p. 36).

Students who need to touch what they are learning are more likely to understand the concept of negative and positive numbers when provided with two-color counters or when using money.

5. Situation or context—"Learning is as much a socially shared undertaking as it is an individually constructed enterprise" (p. 39). Perimeter is clearer to an athletic student who has been assigned to calculate the amount of tape needed to re-tape the gym floor.

Meece (2003) reported that middle schools are now adopting and applying learner-centered principles to help adolescents learn while adjusting to their rapid physiological and emotional changes. National Council of Teachers of Mathematics (NCTM) concurs with the decision of the National Middle School Association that educators need to "provide a curriculum that is balanced and responsive to their (student) needs, to use a variety of instructional strategies" (Meece, 2003, p. 113). Although the age group is not referred to as middle school, Crick and McCombs (2006) found that learner-centered practices benefited learners and educators in an English case study.

Mehigan (2005) suggested that involving students in assessing the effectiveness of a particular strategy "enables teachers to make success accessible to all students" (p. 560). Educators are to consider the uniqueness of each learner as they assist students in acquiring knowledge from a personal frame of reference. Motivation is necessary to foster the interest of the students so that learning is desired. Unfortunately, many students fail to grasp a new concept because the strategies necessary to process the new information have not been taught. The diversity of learners within the classroom setting and the inability of the typical educator to meet the needs of all students contribute to a comprehension gap in many learning environments. This gap is present in students of single-grade, as well as multigrade, classrooms. Academic success results when students are taught within a situation or context to which each student can relate.

As recommended by Murphy and Alexander (2002), individual differences of the learner are the focus of the current study. Manipulating the objects allowed students to monitor their mental processes (Murphy & Alexander, 1994) as they completed assignments. The current study utilized an instructional strategy that considers the needs of students who may need to touch what they learn. At the same time, manipulatives heightened the interest of students while doing math.

Definition of Terms

Brain-based learning: In this environment, strategies are used which appeal to diverse learning styles, endowing each learner with constancy and familiarity (Caine & Caine, 1990, p. 67).

Charter Schools: "Nonsectarian public schools of choice that operate with freedom from many of the regulations that apply to traditional public schools" (U.S. Charter Schools, 2008, ¶ 1). Each school provides a charter which acts as a performance contract, that details the school's "mission, program, goals, students served, methods of assessment, and ways to measure success" (p. 1). The charter is evaluated and renewed according to the time period stated within the charter.

Combination Classroom: a classroom in which exactly two grades are taught together throughout the school day classroom. The same subject is sometimes taught to students in both grades at once, and at other times, they are taught independently for each grade level. Although it is not exactly accurate, these classrooms are usually referred to as multigrade.

K-8: a school that teacher children from Kindergarten to Grade 8.

Manipulatives: hands-on activities, interactive objects, or technology, which students manipulate to assist in their understanding of the objectives, presented. Rust (1999) defined mathematics manipulatives as "any hands-on object that the student can physically move in order to discover the solution to a problem" (p. 2).

Multigrade classroom: a classroom in which at least two grades are taught together throughout the school day. Subjects are sometimes taught to students in both grades at once, and at other times, they are taught independently for each grade level. Mathematics is usually taught synchronously.

Structured mathematics manipulatives program: a mathematics strategy in which various manipulatives have been organized and correlated with the adopted mathematics textbooks, mathematics objectives, and specific standards of the state of Florida, which are based on the National Council of Teachers of Mathematics (2008).

Structured use: the use of mathematics manipulatives, which have been, correlated with specific mathematics standards and all textbooks used in the classroom.

Synchronous teaching: simultaneous teaching of at least two different subjects or grades in a classroom during the same period of time.

Assumptions

An assumption of this study was that all of the students would be in a multigrade classroom. Multigrade classrooms are unique in that more structure is needed, especially when teaching a subject to more than one grade synchronously. It was assumed that seventh- and eighth-grade mathematics would be taught synchronously and, therefore, present special problems of teacher preparation and time management for implementing certain manipulatives in the classroom. It was further assumed that the students were being prepared for high school Algebra.

Limitations

This study engaged the seventh- and eighth-grade mathematics students in a multigrade classroom of a small private school. The fact that this was the second year that eighth graders had exposure to me as their teacher may have rendered it difficult to distinguish whether aspects of classroom performance was the result of pre-existing teacher-student relationships or of the use of manipulatives alone. Because I served simultaneously as researcher and teacher, students may have responded to the MAS or participated in a particular manner during observation sessions out of a desire to please me as their teacher. Yet another limitation resulting from my serving simultaneously as teacher and researcher is the halo effect, which Meier, Rich, and Cady (2006) defined as the result of teachers "applying what they know about . . . students" in rating their performance (p. 71). To counter this halo effect, an independent teacher observed and recorded two class sessions along with me and compared observations with me following each.

Another limitation of the study was my bias towards the use of manipulatives in the mathematics classroom, which may have inadvertently caused me to present the lessons using manipulatives with more energy than when I taught using the textbook only. My commitment to the use of manipulatives in the classroom was a driving force behind this study, making it difficult for me to teach without added energy when they were available.

An additional limitation was that the study was set within a small multigrade school where only a convenience sample comprised of a single class could be used, resulting in the impossibility of randomizing groups and the sample having to serve as its own control. Given the small sample, multigrade sample, the results may not be applicable to larger, single-grade classrooms; however, the results may be of importance to classrooms that have more than two grades.

Significance of the Study

The seventh and eighth graders at the school used in this study are taught together throughout the day in a combination, or multigrade classroom where their seventh- and eighth-grade mathematics teacher, who generally teaches them most other academic subjects as well, is required to prepare them for high school Algebra irrespective of whether they entered seventh grade at level. With these high demands, the multigrade teacher rarely finds sufficient time to consider what manipulatives would work best while teaching specified standards.

Aligning mathematics standards for seventh and eighth graders with textbooks for both grades and appropriate manipulatives for simultaneous instruction allows the multigrade teacher to teach a standard only once and saves time that may be needed elsewhere. Under normal circumstances, the multigrade teacher follows the unique sequence of the prescribed mathematics textbook for each grade in the classroom separately, resulting in the duplicated effort of teaching the same area of mathematics at different times and the necessity of the teacher dividing his or her attention between groups working on different concepts and at the same time. In an aligned mathematics program, seventh- and eighth-grade math students will, for example, be required to add and subtract fractions. The teacher presents the topic to both grades at the same time, guides students through use of the manipulatives, and then allows them to work independently on practice problems appropriate to their individual levels, usually from their grade appropriate textbook. In this study, I examined the impact of a structured mathematics manipulatives program on attitudes of multigrade mathematics students. In the structured math program, the seventh- and eighth-grade math standards, textbooks, and appropriate manipulatives had been aligned for use on the same day.

When the TIMSS was conducted in 2003 (National Center for Education Statistics, 2004), U.S. students showed slight improvement over some European students. Unfortunately, U.S. eighth grade mathematics students were still outscored by developed nations such as, Japan, Hong Kong, Australia, and Sweden. The mean scores of the TIMSS for U.S. eighth grade mathematics students have risen with each administration from 1995 to 2007; yet they continue to lag behind their Asian and some European counterparts. Creative mathematics programs are necessary to enable middle school students to master concepts necessary for higher level mathematics courses that these students will face in high school. Researchers (Ernest, 1994; Leinenbach & Raymond, 1996) indicated that mathematics manipulatives, which have been coordinated with specific objectives, enhance the middle school mathematics classroom, improving mathematics attitudes and performance. Although little research has been performed on the use of mathematics manipulatives in multigrade classrooms, it is believed that these students and teachers would benefit from structured use of manipulatives, as well.

While programs such as those in Milwaukee (Ham & Walker, 1999) and Texas (Texas Education Service Center Region VI , 2006), where teachers instructed students with specific manipulatives and interactive mathematics activities, have resulted in improved mathematics performance and improved attitudes towards mathematics, no structured manipulatives program correlated with state standards has been established to guide teaching in seventh and eighth multigrade math classrooms. Up to this point, all reported research appears to have been designed for and implemented in single-grade classrooms. The current study was designed to fill this gap.

Multigrade classrooms are common in charter schools in the U.S., enrolling more than one million students each year (U.S. Charter Schools, 2008). They are also common in Canadian school districts (Roberts, 1999), developing countries around the world, and many private school systems in the U. S. and worldwide. There are more than 62,000 students enrolled in North American multigrade classrooms of the parent organization of the current study (Adventist Education Statistics, 2003). Multigrade teachers have less preparation time for each lesson that they teach because they usually teach at least four different subjects to at least two different grades throughout the day. Still, in spite of their teachers' necessarily limited time and divided attention, students in multigrade classrooms are expected to fulfill the same mathematics requirements as students in single-grade classrooms and on the same schedule. As no research was found which examined the impact of a structured mathematics manipulatives program on the performance and attitudes of students in multigrade classrooms, this study is offered to provide such needed information.

Author and educator Harry K. Wong (Wong & Wong, 2004) suggested that in the typical classroom, students are actively engaged in their learning only 35% of the time. Students are not actively engaged while listening to a lecture, answering textbook questions, or completing worksheets alone. Unfortunately, when at least two grades of mathematics are taught synchronously to different grades of students, worksheets and textbooks are the easiest method of delivery. The International Center for Leadership in Education (2006) suggested that all school districts provide students with a rigorous curriculum, which is relevant to actualities of the world they interact with beyond the walls of their school. Although such actualities may be described in textbooks, Marzano and Pickering (1997) observed that using academic skills to explore and better understand the world outside of books reinforces students' sense of the value of the information and skills that they are taught. Manipulatives enable students to apply the mathematics concepts in a manner that allows the information to seem useful. When math concepts appear to be useful outside of the classroom students are more successful at problem solving (Schommer-Aikens, Duell, and Hutter (2005).

Results of the brain-based mathematics strategy of the current study are significant in several spheres. First, this study provides a rigorous, brain-based, and learning-centered strategy that allows students to make application to the real world. Second, the structured mathematics manipulatives program offers teachers in multigrade schools a tested mathematics strategy that is sensitive to the scheduling and organizational needs of their classroom. Third, since the manipulatives have been correlated with state standards and adopted textbooks, multigrade teachers can be confident that they are meeting the curriculum requirements as they follow the guidelines. Finally, all mathematics teachers of seventh and eighth graders, who desire a teaching strategy, which engages the learner and is brain-friendly, will benefit from having an organized set of manipulatives, accompanied by a manual, ready for daily use in the classroom. With such a program in place, seventh- and eighth-grade students in multigrade schools will be more apt to work longer and harder during math time. Students will also be more likely to believe that they can succeed in math, thus allowing them to enroll confidently in advanced math courses in high school.

This study can promote positive social change by presenting an increased awareness of a structured mathematics manipulatives program, which may help multigrade students have a better attitude towards mathematics. If students have a more positive attitude towards math, and feel that the course is useful, they may perform better in class (Mason, 2003; Schommer-Aiken, Duell, & Hutter, 2005; Morge, 2007). If they perform better their test scores may improve and they may earn higher math grades (Zimmerman et al., 1992). With improved math attitudes and grades students may be more likely to stay in school longer and even select careers that require advanced mathematics (Hagerty, Smith, and Goodwin, 2010).

This study contributes to the body of knowledge on the effect of using manipulatives, aligned with mathematics textbook and standards, on students in multigrade classrooms learning mathematics. Multigrade educators may be encouraged to use a wider variety of manipulatives in an intentional and organized manner in the future.

Summary

In this chapter, I explained the problem statement, the need to provide a structured mathematics manipulatives program in seventh- and eighth-grade multigrade classrooms, and the impact such a program can make. The challenges faced by seventh- and eighth-grade mathematics students in the United States remain evident, as discussed in this chapter. Brain-based learning and learner-centered principles have clearly shown the need to meet learners where they are. Teachers have been successful in reaching mathematics students using mathematics manipulatives in single-grade classrooms.

Chapter 2 contains a more detailed discussion of the literature related to mathematics manipulatives as well as a discussion of multigrade classrooms. The relationship between attitudes and student performance is examined. The definition, purpose, and a brief history of manipulatives are also in chapter 2. A brief look at selected successes with manipulatives follows the history. An analysis of the literature and how a structured program can enhance the multigrade classroom is also presented.

Chapter 3 includes a discussion of the methodology of the study. The research design, including the research with five related hypotheses is discussed. The population and related sample are described in relation to the community of the sample. A description of the instruments, Mathematics Attitudes Survey and Classroom Observation Checklist, along with reliability and validity, are described in chapter 3.

A detailed description of the quantitative data collected, using the Mathematics Attitudes Survey and Classroom Observation Checklist, is presented in chapter 4. The statistical analyses, using SPSS for Windows version 15, are also in chapter 4. Additionally, a discussion of each hypothesis with the results is found.

An in-depth summary of the results is presented in chapter 5. The implications of these results are discussed, with particular attention to the importance for eighth-grade students and their teachers. The recommendations for further study also include a caution for unstructured manipulatives use in the classroom.

CHAPTER 2:

REVIEW OF LITERATURE

Introduction

A thorough search of scholarly literature reporting structured manipulatives programs using students in multigrade mathematics classrooms rendered limited results. Even less literature was found on manipulatives and self-efficacy in the multigrade classroom. The available research focuses on an important but narrow segment of classrooms, which exist throughout the United States, primarily in rural settings and small school systems. The fact that little research has been conducted in this area validates the need for an additional study and information. The literature review is, therefore, grounded in research related to mathematics attitudes, mathematics achievement, and general use of manipulatives in the mathematics classroom. Also included is an overview of the multigrade classroom and challenges faced by its teachers.

I began collecting literature for this study by searching the following databases: Academic Search Primer, Education Research Complete, ERIC, ProQuest, PsychARTICLES, PsychINFO, SocINDEX, and Teacher Reference Center. I used the following key words: *algebra, attitudes, brain based learning, math, math attitudes, mathematics, mathematics attitudes, middle grades, middle school, multigrade classrooms, multigrade learning*, and *multigrade teaching*. I considered titles with full text availability for the past five years as well as appropriate historical references dating farther back I read nearly 300 abstracts, half of which comprised my original annotated bibliography. Most of these were then printed and filed in five plastic transportable storage bins. Using the key words stated above, I followed the same procedure for an internet search using Google scholar as the search engine. I used this same method to retrieve materials from three county library systems in Florida: Alachua, Duval, and Orange.

I organized and filed the acquired articles and book excerpts according to the following categories: math attitudes, math manipulatives, multigrade learning, and theoretical framework. Similar literature within the categories was combined summaries were written. I began the literature review in 2005 and have made updates of some reports as needed.

This review begins with a look at literature related to brain functions and mathematics, followed by student beliefs while learning math, which is followed by a working definition, history, purpose, and successful uses of manipulatives. Following the history is a definition and discussion of the multigrade classroom. In the final section, critical analysis and concerns related to manipulatives in the classroom are explored. The next section includes a discussion of the multigrade mathematics classroom. In addition, literature related to the use of differing methodologies to investigate the outcomes of interest is reviewed.

Brian Functions and Mathematics

It is the job of the brain to receive, analyze, and store information from past experiences in order to make learning and recalling information possible (Bogoch, 1986).

Merzenich (1995) designed computer games for language impaired students using the premise that healthy neurons form new neuronal connections that can be trained to be more efficient and process information faster within the brain. The computer program Fast ForWord was developed to train and enhance cognitive functions such as attention and sequencing, thereby reducing language impairments (Mezernich et al., 1996). Educators who use the program have observed that language impaired students have not only improved up to two years (Tallal, Mezernich, Miller & Jenkins, 1998), but gains have been made in other academic areas, including mathematics (Scientific Learning, 2010). The ability to process language and mathematics require related brain functions.

Bull and Scerif (2001) studied 93 children between six and eight years old. They found a significant correlation with nearly every executive function of the brain and mathematical ability. Executive functions are cognitive abilities, which enable the initiation and cessation, as well as the monitoring and changing of behaviors. Executive functions are necessary in order to deal with novel situations. Students with higher mathematical ability exhibited a higher working memory. Newly processed information is not available to connect to the required data for problem solving without working memory (Swanson, 2004). Bull and Scerif (2001) found that children with math difficulties were less able to inhibit irrelevant information and strategies. In mathematics an established strategy must sometimes by inhibited, or abandoned in favor of a more appropriate one. The inability to inhibit previous information may tie up working memory that is necessary when completing activities required for adequate arithmetic development.

According to Butterworth (2005), adequate development of arithmetic takes place as we understand implications of the numbers in sets and are able to manipulate them. Grasping the concept of numbers in sets is also known as numerosity. When Rouselle and Noel (2007) compared 45 children with mathematics learning disabilities to 45 of their normal achieving peers, they found no significant differences in numerosity; however, the math disabled students displayed difficulty with the semantics of numerical symbols and corresponding number magnitudes. Scientists (Castelli, Glaser, & Butterworth, 2006) at the University College London Institute examined brain activity of subjects while completing two different types of mathematical skills. Brain activity of the subjects was first analyzed while counting objects. In the second observation brain activity of subjects was analyzed as character traits were assessed. The results indicated that although the left and right parietal lobes are activated during arithmetic operations, one area of the intraparietal sulcus was more engaged in numerosity that the other. A separate study at University College London Institute (2007) confirmed that dysfunctions of the parietal lobe could result in mathematics disabilities. After studying patients with brain trauma, Grafman (2000) suggested that when the right parietal lobe is damaged the left lobe may not activate strongly enough to calculate and process number functions, yet the right parietal lobe attempts to compensate for the loss with. Mathematical difficulties seem to follow students throughout their school experience.

Anderson (2010) conducted a longitudinal study of children with various learning difficulties. Students who had difficulty learning math at age nine did not catch up with their peers by the time they turned 13 years old. The math difficulties included factual, conceptual, procedural, problem solving, and telling time. With early detection and educational adjustments, students need not suffer long term mathematical difficulties (University College London Institute, 2007). Anderson (2010) recommended that learning mathematics should include making connections between numerical and mathematical symbols using concrete objects. One such method of making connections is mathematics using concrete objects is manipulatives and will be discussed later in this chapter.

Mathematics Attitudes and Performance

After examining several approaches to improve the mathematics curriculum in the United States, Marzano (2003) concluded, "there is simply not enough time in the current system to address all the content in the state-mandated standards and benchmarks" (p. 25) He recommended that school districts find a method of increasing the amount of student instructional time if mathematics achievement is to be maximized. It is not practical to increase the school year. Neither does it mean that more topics are to be added to the textbooks or curriculum. In fact, there are 175% as many topics addressed in U.S. mathematics textbooks as there are in German textbooks; there are 350% as many when compared to the Japanese. Despite the increased number of topics in the textbooks, the TIMSS, 2007 indicated that eighth grade mathematics students in the United States remain behind their European and Asian counterparts (National Center for Education Statistics, 2009). If increasing the number of standards or extending the school year are not realistic options, how can mathematics performance be improved?

Mathematics proficiency, as described by the National Research Council (NRC, 2001) has five interwoven strands that cannot be separated if students are to succeed at learning and performing math. Conceptual understanding of mathematics concepts cannot take place without mastery of adaptive reasoning, also known as logical thought, explanation, and justification. Procedural fluency, which is the ability to carry out mathematics skills accurately, will not be successful without strategic competence and productive disposition. The productive disposition of a mathematics student refers to the "habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (p. 5). Self-efficacy is "a context-specific task, a judgment of one's capabilities to execute specific behaviors in specific situations" (Pajares & Miller, 1994, p. 194). When comparing gender, perceived usefulness of math, and mathematics self-efficacy, Pajares and Miller (1994) found that no other variable had a stronger direct effect on performance than self-efficacy. Even when parents and teachers adopt high academic aspirations for students, significant achievement eludes students who lack self-efficacy (Zimmerman, Bandura, & Martinez-Pons, 1992). In other words, it is possible that "perceived efficacy to achieve motivates academic attainment both directly and indirectly by influencing personal goal setting" (p. 674). It would seem that academic achievement is linked with attitudes and goals.

The relationship between mathematics attitudes and performance has been studied for several decades. Stodolsky (1985) argued that when students are repeatedly presented with the idea that the expert, also known as the teacher, explains the methods for learning math, it makes sense that the student believes that this is the norm for learning math. Consequently, those who have never completely achieved an understanding of the principles behind basic mathematics when they were young are not surprised, when later presented with more advanced math topics such as statistics, that they still don't "get it". Therefore, the cycle repeats itself; they fail to engage with the material and passively await explanations from their teachers (Stodolsky, 1985), which helps them no more than it did the first time. It is no wonder that their attitudes towards learning math remain negative. Ma and Willms (1999) offer the following set of questions for taking inventory of a student's overall attitude towards learning math and for predicting his or her achievement and quality of participation in advanced mathematics courses:

Does the student like mathematics?

Does the student perceive it to be useful in daily life?

Is the student confident in his or her ability to learn math?

Burns and Humphreys (1998) suggested that gaps exist in the teaching of algebra. These gaps prevent students from understanding the material as well as comprehending the significance of Algebra for life. Students must have faith in their mathematics ability in order to succeed in math. In a study of 599 high school students Mason (2003) found that "the more students believe in their ability to solve difficult problems…maths' usefulness…and the importance of understanding a procedure and not only its memorization…the better their grades" (p. 79). Hence, belief in ability and understanding results in improved mathematics achievement; consequently, low performing students have negative beliefs about their abilities.

Spangler (1992) suggested that the cycle of negativity towards mathematics that leads to poor performance could be broken. Spangler encouraged teachers to find teaching methods that enable students to discover their mathematics beliefs and reverse the negativity. Eccles et al. (1993) proposed that the transition from elementary school to middle school is a strong factor in students liking math, and low-achievers lacking motivation. Diaz-Obando, Plasencia-Cruz, and Solano-Alvarado (2003) found that student "beliefs impact powerfully on the ways in which students learn and use mathematics in a given context" (p.161). Simultaneously, beliefs provide a foundation for interactions within the learning environment. Interactions within the learning environment are necessary to guide learners through mathematics and to help develop mathematical ability. Students who lack ability may put forth more effort if they perceive the knowledge to be useful. Schommer-Aikins, Duell, and Hutter (2005) found "that both general epistemological beliefs and mathematical beliefs may play a role in students' problem-solving performance" (p. 301). They concluded that middle school students who believe mathematics to be useful would put forth more effort, even if the material seems challenging. Middle school teachers are encouraged to "make mathematics tasks intrinsically interesting…fun, and applicable to students' lives" (p. 302). Students who enjoy mathematics are confident in their ability; students who are confident in their ability obtain higher mathematics grades (Kloosterman & Cougan, 1994). Ma and Willms (1999) found that during the transition from Grade 8 to 9 and Grade 11 to 12 large proportions of students drop out of advanced mathematics. Student math achievement in Grade 8 played a dominant role in their career path. These results allow one to infer that attitude and achievement are linked to career goals.

Thomas (1980) claimed that students' motivation affects their test performance in all academic subjects directly and indirectly. Self-concept and self-esteem are shaped by a history of success and failure, which subsequently provide motivation—or a lack thereof—on tests. Brinson et al. (2002) revealed that the quest for higher standardized test scores negatively affects student performance. Brinson et al. contended that, "When resources are limited and jobs are on the line, leaders are often forced to make decisions that are expedient but not necessarily prudent" (p. 24). Many times a school system must sacrifice a well-rounded educational program in order for students to score well on tests; however, high test scores do not necessarily reflect comprehension of the subject matter or preparation for life.

Kifer (1975) found that student personality characteristics and academic success or failure are reflective of years of school experiences. Even momentary success is not sufficient to altar years of negative reinforcement. Students need intensive and extensive exposure to success in order to excel in mathematics. Schoenfeld (1985) investigated student beliefs about mathematics and their actual performance in a high school geometry class. As with other academics, mathematics students who consistently applied themselves found the course less rigid, earned higher grades, and enjoyed it more than students who did not apply themselves. Unfortunately, most of the students in the study experienced mathematics by rote memory, which does not allow for long-term appreciation of or interest in the material (Lester et al., 1989).

The implications regarding mathematics attitudes and performance are clear: Teachers need to help students develop positive attitudes towards mathematics and their ability to succeed in the subject. Academic experiences should be structured in a manner that will maximize a student's perceived academic efficacy (Zimmerman et al., 1992,). This recommendation is consistent with that of Kifer (1975) who concluded, "those students who experience success develop highly positive views; those who experience failure do not" (p. 194) Educators are encouraged to implement practical instructional strategies, which consider personality variables. It is also necessary for the material to be meaningful and interesting in order to build positive attitudes towards mathematics. The alternative is a lack of confidence, which results in a sense of helplessness towards selected types of math problems (Lester et al, 1989). Perhaps educators would be more inclined to seek out manipulatives programs if their purpose was understood.

Mathematics Manipulatives Definition and Purpose

Mathematics, according to Durmas and Karakirik (2006) is, "often seen as an isolated experience area performed just in schools alienated from real life" (p. 2). They counter this idea by defining mathematics as, "a systematic way of thinking that produce solutions to problems by modeling real-world situations" (p. 2). This places the task of modeling the abstract for students so that they can apply the concepts to the real world. Durmus and Karakirik (2006) suggested that if mathematical concepts were represented in a meaningful way, students would be better equipped to recognize the connections between the classroom and life. Dienes (1963) discussed the idea that a meaningful connection within mathematical settings actually defines the contextual mathematics experience.

Manipulatives are hands on activities, interactive objects, or technology, which students manipulate to assist in their understanding of the objectives presented. Heddens (2008) described manipulatives as "concrete models that involve mathematics concepts, appealing to several senses that can be touched and moved around by the students" (p. 3). Rust (1999) defined mathematics manipulatives as "any hands-on object that the student can physically move in order to discover the solution to a problem" (p. 2). When two key features of this definition are considered, hands on and solution-oriented, mathematics manipulatives become broader than simply number counters to add and subtract. Moyer and Jones (1998) advised teachers to present manipulatives to students as tools and materials that are to be used daily. Students should be provided time to explore the use of manipulatives, investigate handling of the objects, and examine attributes in order to construct understanding based on management of the manipulatives. Formal programs, such as Borensen's (1986) *Hands on Equations,* foster algebraic thinking and provide a systematic guide to the use of manipulatives. Leinenbach and Raymond (1996) used the terms “manipulatives” and “hands-on” when discussing their study involving the use of the algebra readiness manipulatives program Hands-on Equations to solve algebraic equations. Picciotto (2006) suggested that Zoltan Dienes was the first teacher on record who used manipulatives to help students physically touch algebraic concepts.

History of Mathematics Manipulatives

Dieines designed Dienes Blocks to demonstrate the Distributive Law of mathematics to students (Picciotto, 2006). The original blocks were designed as three-dimensional flats, and included small unit squares arranged in sets of ten by ten, which represented 100 squares. They have evolved into three dimensional, base ten blocks, which include flats as well as units, rods, and cubes. When Dienes used base-ten blocks, he allowed the "rod" (10) as x and the "flat" (100) as x^2, to illustrate the distributive law (Dienes, 1963; Picciotto, 2006). Dienes (1963) introduced the base-ten blocks so that students would have a physical understanding of math, in turn, leading them to a conceptual understanding. Peter Rasmussen modified the work of Dienes as he worked with base-ten tiles (Picciotto, 2006), creating a model upon which the popular Algebra Tiles and many other manipulatives were based.

Goins (2001) indicated that the base ten blocks “provided the opportunity for them (students) to see that one has to multiply all parts or place values in one number by all parts or place values in the other number” (p. 4). For a visual or tactile learner, working with base-ten blocks enables equations such as $(b^2 + 2b + 1)\ (b + 1) = b^3 + 3b^2 + 3b + 1$ to make sense. The clarity of the Dienes blocks, now called Base Ten Blocks, allows Algebra students to see and manipulate various concepts. Base Ten Blocks are standard in mathematics manipulatives kits today (ETACuisenaire, 2008) and can be used to help students comprehend whole numbers, decimals, and the distributive property. The development of Pattern Blocks, Algeblocks and many other manipulatives can be traced to Base Ten Blocks.

Current Research Use of Manipulatives

The National Council of Teachers of Mathematics (NCTM) provides tested resources and professional development suggestions to ensure the highest quality of mathematics education in the United States. The NCTM (2008) encourages mathematics educators to make a broader use of manipulatives than has existed in the past. This section will review examples of successful implementation of manipulatives.

Manipulatives are not new to the teaching of mathematics. They are popular in primary grades, but are seldom used after sixth grade. Primary grade teachers use manipulatives so that students can touch items related to the concept being taught. After exposure to a concept, the brain must be given the opportunity to "try it, tinker with it, play with it, watch it, and make it work" (McCarthy, 2000, p. 11). Primary teachers, curriculum designers, and textbook makers realize there is a relationship between doing and understanding. They recognize the importance of providing the brain with challenges that foster learning connections (Hannaford, 1995). Buehl and Alexander (2005) found that students with lower levels of motivation and task performance had a higher conviction of authority as the source of knowledge. When the authority figure takes complete control of the learning experience students tend to become less active. In traditional mathematics classrooms, the teacher transmits knowledge to passive students. Understanding of subject matter occurs when procedural instructions are followed successfully. Classrooms in which mathematical students are allowed to create, model, and manipulate the concepts help students take charge of their own learning (Cobb, Wood, Yackel, & McNeal, 1992). This is consistent with Hannaford (1995), who advises teachers that the brain must have challenging activity to learn, regardless of the grade in school. Burns and Humphreys (1990) presented interactive mathematics lessons, which require students to investigate, apply, and prove concepts. The use of such manipulatives as counters, dice, and geoboards is built into many primary grade textbooks. Does the need to touch the concept diminish after grade five? Burns and Humphreys (1998) proposed that teaching mathematics concepts, outside the realm of memorized facts, is necessary to middle school students understanding the material presented. For mastery of many concepts, memorization is necessary, but comprehension of the principle is necessary. Comprehension of a concept is successful when the brain has an opportunity to activate learning. Examples of activities that engage the whole brain are problem solving, creating, forming hypotheses, tinkering, and drawing conclusions (McCarthy, 2000).

Graphing calculators have become commonplace in high school mathematics classes (Drier, Dawson, & Garofalo, 1999). The use of this technology expedites classroom calculations but educators are warned that appropriate mathematical and technological comprehension should precede the use of technology in the classroom. With advancing technology has come the availability of virtual manipulatives. Brown (2007) compared sixth graders using virtual manipulatives from the internet to concrete pattern blocks when learning fractions. Students using the concrete pattern blocks outperformed students using virtual manipulatives on the post-test.

While using manipulatives arouses student interest in mathematics, Heddens (2008) cautioned teachers to select those that are developmentally appropriate for the students and are in line with specific concepts. It is also necessary for each student to use the manipulatives, not just the teacher, or a small select group of students. Spear-Swerling (2006, p. 5) suggested, “If properly used and appropriately integrated with this type of instruction, manipulatives can be very helpful in concept development, as part of a broader mathematics program for youngsters with learning disabilities.” Regardless of age or disability, Taylor and Brooks (1986) advocated that once students overcome mathematics anxiety they can become successful mathematics learners. Manipulatives and other hands on activities are recommended to help learners overcome anxiety towards math and learn through simulation of real life experiences. Park (1997) studied Anglo, Korean, Mexican, and Armenian-American students in secondary school. She discovered that males and females in all four ethnic groups learned better, when practical and interactive learning opportunities, that engage the entire physique, are engaged in the classroom. These experiences should take place daily in the classroom. Such diverse curricular should be the norm in school systems which serve heterogeneous populations (Kennedy 1997).

Cordova School in Arizona upon a hands-on mathematics program and found that mathematics anxiety is minimized for students and teachers when manipulatives are used. Tankersley (1993) reported that implementation of hands on mathematics at Cordova School revitalized the staff, resulted in higher state test scores, and improved attitudes of students and parents towards math. Ernest (1994) evaluated the effectiveness of a mathematics manipulatives project. She noted that students who used manipulatives seemed to comprehend tasks with accuracy, employed discovery, and problem solving strategies, were anxious to share their discoveries and solutions, engaged in lively interaction related to the content, and were excited about learning. Additionally, teachers in the study reported that student performance on classroom assessments increased by a minimum of 46% when manipulatives were used to teach mathematics (Ernest, 1994). In other words, she observed that students learned, as well as used mathematics appropriately when using manipulatives.

The Math Workshop (2007) is a pre-packaged mathematics manipulatives box and binder prepared for grades one through four. The publishers have separated the mathematics curriculum for these four grades into what they have termed “12 different strands of mathematics: algebra, brainteasers, calendar, estimation, fractions, geometry, graphing, measurement, money, number operations, puzzles and shapes, time” (The Math Workshop, 2007, p. 5). Other studies describe less structured, albeit successful, use of manipulatives. Quinn (2001), for example, analyzed several activities intended to aide middle school students in their comprehension of probability using attribute blocks. Mankus (1998), on the other hand, developed several algorithmic and distributive activities for use with base-ten blocks in the middle school mathematics classroom. Scavo (1996) developed lessons to use with tangrams to assist students in becoming familiar with polygons such as trapezoids and pentagons, as well as to reinforce congruence, and to determine area. The Chinese are credited with the invention of the seven-piece tangram puzzle. In grades K-8, they are used to develop spatial-visualization skills, as well as the introduction and reinforcement of geometrical concepts (Scavo, 1996). Allen (2007) also explored geometric uses of manipulatives with pattern blocks. Student participation increased when fifth graders used pattern blocks in math class. It was also noted that understanding of concepts improved when the same fifth graders used manipulatives.

Some textbook companies include manipulatives activities. In the middle school mathematics textbook series, prepared by Larson, Boswell, Kanold, and Stiff (1999), several uses for manipulatives are suggested that help educators teach selected mathematics standards. Thornton and Lowe-Parrino (2004) designed a series of teaching strategies and hands on activities, which contains lessons applicable for middle school classrooms. Both programs provide detailed teacher instructions implementing the manipulatives lessons, as well as guidelines for making manipulatives, if appropriate. In both textbook series the following topics which include manipulatives activities are included: proportion using graph paper; rational numbers using number counters; geometry using dot paper; number operations using square tiles and number counters; data analysis using number cubes; and linear functions using Geoboards.

Hands-on Equations (Borenson, 1986) is a standalone manipulatives program, which provides students with concrete representation of algebraic symbols and processes using game pieces. “The algebraic processes are represented by physical actions upon these pieces…as the equations are solved; the child can see what he’s doing” (Borenson, 2003, p. 4). This program uses the whole brain to solve algebraic equations. After examining the *Hands-on Equations* (Borenson, 1986) program, Suh and Moyer (2007) concluded that students are able to translate among pictures, manipulatives, symbols, and written representations. With this program, even third graders are motivated to comprehend algebraic concepts.

The results of a study by Leinenbach and Raymond (1996) convinced Marilyn Leinenbach to use manipulatives on a regular basis in her eighth grade classroom. She noticed that manipulatives helped her students visualize, comprehend, and apply concepts and objectives. While Marilyn Leinenbach (Leinenbach & Raymond, 1996) taught algebra readiness skills to her eighth graders using *Hands-on Equations* and the eighth grade textbook she found clear differences. When manipulatives were used, student scores were higher than when the textbook alone was used. About 23% of the students whose scores were in the “C” range raised their grades above 80% while using manipulatives. A significant comparison study showed that 42% of the students earned an

"A" average on the algebraic work with manipulatives while only 14% earned "A's" while using the textbook. They concluded that when eighth-graders used manipulatives they performed better and reflected a more positive outlook towards Algebra than when using the textbook alone. Student comments such as "it was funner… when you actually touch the problem it's easier…made me want to learn" (p. 6) indicated that their attitudes towards mathematics were more positive during manipulatives use. Table 2 displays the difference in student performance when using the textbook alone and when using manipulatives with the textbook.

Table 2

Comparison of Class Averages using Textbook and Manipulatives

	Class Averages	
Class period	Textbook	Manipulatives
1st	65%	82.38%
2nd	70.47%	81.28%
3rd	75.07%	85.29%
6th	81.29%	87.82%
7th	72.16%	82.1%

Note. From "A Two-year Collaborative Action Research Study on the Effects of a Hands-on Approach to Learning Algebra," by M. Leinenbach and A. M. Raymond, 1996, Presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education. Reprinted with permission of the author.

It is clear that student performance improved during each class period when manipulatives were added to the classroom.

Innovations in technology have fostered the use of virtual manipulatives, the most recent type of object manipulation for mathematics. Bolyard and Moyer (2006) found that sixth grade students who used Virtual Chips, Virtual Integer Chips with Context, and Virtual Number Line made significant pretest to posttest gains. These results indicate that virtual manipulatives support students understanding of addition and subtraction of integers. Also notable is that specific features shared by all three virtual manipulatives, such as “interactive capabilities, multiple representations, and immediate feedback, appeared to be most important in supporting learning” (p. 5). This rang true of even the most challenging subtraction item. These results are consistent with Suh and Moyer’s (2002) findings related to virtual and physical manipulatives. Virtual manipulatives promote linking of visual and symbolic; step by step processes; and self-checking systems. The immediate feedback of virtual manipulatives encourages the student to focus on the specific mathematics tasks more so than do physical manipulatives (Moyer-Packenham, Salkind, & Bolyard, 2008).

Niess and Erickson (1992) found that mathematics students who used manipulatives, real-life activities, technology, and problem-solving strategies aligned with curriculum standards experienced significant achievement gains. This is consistent with Tichenor (2008) who advised, “To help keep students focused and on-task when using manipulatives, teachers must be clear about their rules and expectations…teachers must make explicit connections between the mathematics concept and the manipulatives used" (p. 4). Heddens (2008) proposed that using manipulatives in teaching mathematics would help students learn:

1. To relate real world situations to mathematics symbolism.
2. To work together cooperatively in solving problems.
3. To discuss mathematical ideas and concepts.
4. To verbalize their mathematics thinking.
5. To make presentations in front of a large group.
6. That there are many different ways to solve problems.
7. Those mathematics problems can be symbolized in many different ways.
8. That they can solve mathematics problems without just following teacher's directions.

These skills are similar to brain-based learning strategies, which encourage optimal learning experiences in a non-threatening environment. Organization of multigrade classrooms for acquisition of the necessary math skills provides more of a challenge, as the next section discusses.

Teaching in Multigrade Classrooms

In a multigrade classroom, at least two grades are taught together throughout the school day in the same classroom. Sometimes the subjects are taught as one and at other times, subjects are taught independently for each grade level. When there are only two grades, the term combination classroom is sometimes used. In the school of the current study, every classroom except kindergarten has a minimum of two grades. This section provides a brief overview of what it is like to teach in a multigrade classroom.

Single grade classrooms are the norm in the United States; however, multigrade classrooms are more common worldwide. In fact, around 30% of the children around the world are taught in multigrade environments (Consortium for Research on Educational Access, Transitions and Equality [CREATE], 2008). Most multigrade classrooms in the United States exist in small schools or small school systems. This is the case of the current study. Multigrade classrooms have a lower teacher-student ratio than that of single grade classrooms. This ratio provides the opportunity for each student to progress at his or her own pace (Anderson, 1991). Multigrade classrooms provide a more flexible learning environment (Blum & Diwan, 2007). Unfortunately, delivery of instruction to various grades in the same classroom results in challenges for the multigrade teacher, not usually encountered by the single grade teacher.

As with a single grade classroom, organization is the key to effectiveness (Messer, 1993) in the multigrade classroom. Multigrade teachers need training on how to "organize teaching in the complex multigrade classrooms, how to organize the classroom itself, and how to utilize school resources and spend teaching time productively by combining educational curricula or specialized strategies" (MUSE, 2010, p. 14). "The multigrade classroom can be more of a challenge than the single-grade classroom. Skills and behavior required of the teacher may be different, and coordinating activities can be more difficult" (Miller, 1991). Unfortunately educational preparation consists of professional preparation only for single-grade classrooms, as if there are no multigrade classrooms, or that instruction within them can be the same as the former (MUSE, 2010). Blum and Diwan (2007) contended that pre-service and in-service training is insufficient for multigrade teachers. The multigrade teachers are "often simply left to use whatever strategies they are able to devise themselves" (p. 25). The aloneness and lack of preparation leave the multigrade teachers with attitudes that negatively affect their performance (MUSE, 2010).

Lesson planning for multigrade classrooms is time consuming. It has been estimated that a teacher might have up to 60 preparations daily in a multigrade classroom (Oliver, 1992). Teachers of multigrade classrooms are required to manage children who are at various grade and developmental levels. Hoffer (1991) observed that in some cases these levels can range from first grade through high school. "Teachers of small schools often encounter unique problems related to curriculum management, class size, scheduling, and grouping for instruction (Hoffer, 1991, p. 7). One of the greatest challenges for teachers in multigrade classrooms is time management due to the extensive amount of lesson preparations and presentations. Cross-age teaching and tutoring allow these teachers to maximize each moment in the classroom (Lee, 1991). Even though students of various grades are taught at the same time, each one is expected to complete assignments at his or own grade or developmental level (Campbell & Burton, 1991). Some multigrade teachers reduce preparation and grading time by adapting cooperative learning and hands on activities (Oliver, 1992). Miller (1991) suggested that the six key dimensions of successfully teaching in a multigrade classroom are classroom organization, classroom management and discipline, instructional organization and curriculum, instructional delivery and grouping, self-directed learning, and peer tutoring. Little, Pridmore, Bajracharya, and Vithanapathirana (2006) reported on an open-ended survey in India, which asked 72 multigrade teachers what were their greatest training needs. The most common response (76% of those surveyed) was to have syllabi designed especially for multigrade classrooms. Time management skills (42%) and teaching different grades simultaneously with different textbooks (28%) also topped the list. The conclusion reached was that multigrade teachers desire a curriculum with learning activities for multigrade teaching.

When teaching mathematics in a multigrade classroom, the teacher, "must be flexible enough to individualize and use hands-on methods" (Hubbard, 1994, p. 42). Manipulatives should become a regular part of the multigrade mathematics classroom and teachers are encouraged to teach math to all grades during the same hour (Hubbard, 1994). Just as with other subjects in the classroom, it is common for multigrade teachers to present a mathematics topic to several grades at the same time. This is referred to as synchronous teaching, and saves valuable time for the teacher. Once the topic is presented, students complete at level assignments and activities. "A multigrade class has a wide range of achievement, so there is usually a teacher available who has mastered any topic a child needs to learn" (1994, p. 41). While the teacher is circulating, or working in small groups, the students tutor one another.

Little et al. (2006) identified four of the most popular approaches to teaching in the multigrade classroom. These are summarized below.

1. Multiyear curriculum spans: In this approach, all students are taught common topics together at the same time and complete the same activities over a specified period of years. For example, in a seventh- and eighth-grade combination classroom, single grade seventh-grade science curriculum can be taught in the odd years to both grades, while eighth-grade science single grade science curriculum is taught in the even years.
2. Differentiated curricula: All students are taught the same topic, but each grade group engages in activities appropriate for his or her level.
3. Quasi monograde: Each grade is taught separately as if there are two or more classrooms within the classroom. The teacher divides his or her time equally between each grade group
4. Learner and materials-centered: Each student completes a curriculum based, self-paced guide. The teacher assists each student as needed.

Cash (2000) recommended differentiated curricula as the most appropriate for multigrade teaching. CREATE (2008) suggests that a major advantage of the differentiated curricula approach is that different grades can be taught at the same time. This saves time for the teacher, allowing attention to be placed where it is most needed, on the needs of the students. This gives the class the opportunity to learn together as one group. A major drawback is that it “involves teachers restructuring curriculum frameworks for each of two or more grades into one by identifying learning objectives and/or topics in common" (CREATE, 2008, p. 3). Cash (2000) recommended that the curriculum developers and policy makers provide a curriculum structured to the needs of the multigrade classroom. This type of intentional planning is what took place in the structured math program in the current study when the seventh- and eighth-grade textbooks were aligned with the math standards and the manipulatives.

Research Methodologies

Quantitative research methods focus on "controlling a small number of variables to determine cause-effect relationships and/or the strength of those relationships" (Mills, 2003, p. 4). The resulting data utilizes numbers to quantify the relationships. Qualitative research, on the other hand, "uses narrative, descriptive approaches to data collection to understand the way things are and what it means from the perspectives of the research participants (2003, p. 4). Hatch (2002) encouraged the use of qualitative methods so that the participants speak for themselves. While qualitative methods are beneficial for providing detailed descriptions of the sample and their environment (Merriam, 2002); limitations of time and resources may reduce their effectiveness.

When the research design utilizes a survey, a quantitative or "numeric description of trends, attitudes, or opinions of populations" (Creswell, 2003, p. 153) is provided. Surveys provide data, which researchers can use to "describe, compare, or explain individual and societal knowledge, feelings, values, preferences, and behavior" (Fink, 2006, p.1). Three good reasons suggested by Fink (2006) for implementing a survey are:

(a) to set a policy or plan a program, (b) to evaluate the effectiveness of programs designed to change knowledge or attitudes, and (c) to assist in research.

Marzano (2003) found a survey particularly useful for discovering which concepts mathematics educators considered essential. When examining methods, for studying and measuring mathematics curriculum implementation. Huntley (2009) included several qualitative and quantitative methods as having been successful. Surveys, interviews, teacher logs, and student journals or notebooks provide information concerning quality and quantity of curriculum implementation. Both Huntley (2009) and Burstein (1995), are of the conviction that direct classroom observation yields the most complete and reliable information on the success of implementation. However, Burstein (1995) points out that direct observation entails the drawback of generalizing what occurs at a specific point within a school year to an entire school year. The best way to compensate for this drawback is to implement multiple data collection methods. The current study uses a combination of survey and classroom observation as quantitative methods of data collection.

Critical Analysis of Literature

The research on manipulatives cited above discussed the positive impact they can make in the mathematics classroom. When Hawkins (2007) evaluated the effectiveness of manipulatives in teaching fractions to third graders, no statistically significant difference was found between the experimental group and the control group; however, a significant difference was found between the pretest and posttest scores of the group that used manipulatives. The difference in scores of the students who used manipulatives was larger than the control group, but not statistically significant. In careful examination of the control group, it was discovered that these students were older than the experimental group. Hawkins (2007) suggested that the older students would have had more exposure to fractions than the experimental group. The results of this study caused Hawkins (2007) to conclude that "statements by the NCTM arguing for the use of manipulatives for all students need to be re-examined" (p. 94). In spite of the absence of positive results, it must be pointed out that manipulatives did not cause a negative impact on the participants in Hawkins' (2007) study or their learning. Another mitigating consideration is that Hawkins' (2007) study covers the use of manipulatives over a period of only four weeks. A truly negative result regarding the value of using manipulatives to teach algebra was recorded by McClung (1998), who used Algeblocks to teach one section of Algebra I, while using traditional methods to teach a different section of Algebra I students. The students who did not use the Algeblocks outscored the Algeblocks group on the post-test. Both groups received similar instruction with the exception of Algeblocks replacing worksheets for the manipulatives group.

Moyer (2001) analyzed situations in which mathematics teachers used an assortment of manipulatives and found that the function and success of manipulatives varied in each classroom. Moyer (2001) cautioned teachers to collaborate with other teachers and clearly state the purpose of the manipulatives to students. She advises that unless students perceive an explicit math related purpose in the use of manipulatives, they become no more than toys to them. Spear-Swerling (2006) warned, “There can be some pitfalls to manipulatives, especially for struggling students. Manipulatives are potentially confusing if their presentation is haphazard, disorganized, or lacking appropriate guidance and instruction from the teacher” (p. 4).

With the exception of *Hands on Equations* by Borenson (1986), I could find no formal, step-by step middle-school manipulatives program that could be easily used in multigrade classrooms. The Math Workshop (2007) is brain-friendly and organized, but is only appropriate for grades one through four. ETACuisenaire (2008) offers a manipulatives kit for intermediate grades; however, there is no evidence that it has been correlated with state standards or that the activities have been sequenced for any adopted middle school textbook.

A very serious concern about the use of manipulatives was raised by Leinenbach and Raymond (1996) who were unable to determine why the scores of students tested with manipulatives on their desks dropped from 83.77% to 69.89% when the manipulatives were removed and the textbook alone returned. Could it be that the students had become very dependent on the manipulatives? Were they frustrated by the textbook once they realized that a different method was possible? Did the teaching style utilized change once the manipulatives were removed? These questions may be significant, but should be addressed in a separate study.

The research on multigrade classrooms provides suggestions as to how teachers can organize and implement lessons despite the challenges of preparing for and administering instruction simultaneously at different grade levels. While the use of manipulatives and hands-on activities is encouraged (Hubbard, 1994; Bucknor, 1994; Merckx, 2010), documentation of the impact of manipulatives on mathematics learning in multigrade classrooms could not be found. When Messer (1993) presented tips for organizing a multigrade classroom, the top three were *plan, simplify*, and *organize.* Teaching more than one grade in the same classroom requires extensive planning so that the day can flow smoothly and time is used effectively as the students grasp the designated concepts. Multigrade teachers are encouraged to combine lessons that cross grade levels (Cash, 2000; Little et al. 2006), and in doing so, they follow Messer's (1993) advice to simplify. Multigrade classrooms are common in rural schools worldwide, Canadian schools (Roberts 1999), charter schools within the United States, and private schools across the country. In order for a teaching strategy to be successful in some programs, it must fit into the recommended two-year or four-year cycle practiced in many multigrade schools (NAD Office of Education, 2002). No research was found that explored the impact of a structured manipulatives program on students in a seventh- and eighth-grade multigrade mathematics classroom.

The structured mathematics manipulatives program investigated in this study is based on a correlation of lessons for more than one grade level, as is recommended for multigrade teaching (Roberts, 1993; Roberts, 1999). Furthermore, it correlates appropriate mathematics manipulatives with the seventh- and eighth-grade criterion, as set forth in the Southern Union Conference Math Standards and Benchmarks K-8 (2003), Florida Sunshine State Standards (2008), and the *Passport* (Larson, Boswell, Kanold, & Stiff, 2002) textbook series for both grades. Since it is aligned with the textbooks and standards, the structured program investigated in this study can be classified as differentiated curricula, as recommended by Cash (2000) to be used with multigrade teaching.

Conclusion

This section provided research, which encourages teachers to implement mathematics lessons that will capture the attention of the learner and involve them in the learning process. Research such as that completed by Tankersly (1993) and Ernest (1994) revealed that teachers and students have experienced classroom success while using mathematics manipulatives. Spear-Swerling (2006) encouraged the use of manipulatives to foster concept development and positive attitudes towards math; and, Taylor and Brooks (1986) concluded that positive mathematics attitudes contribute to mathematics achievement. Unfortunately, no research was found which examined structured manipulatives use in the multigrade classroom. The next section focuses on the methods used to assess the impact of a structured mathematics manipulatives program on students in a multigrade classroom.

CHAPTER 3:

RESEARCH METHOD

Introduction

The purpose of this quasi-experimental study was to examine the affect of a structured mathematics manipulatives program on the attitudes of seventh- and eighth-grade students in a multigrade classroom. In the structured math program, the math standards for seventh- and eighth-grade, the seventh- and eighth-grade math textbooks used in a multigrade classroom, and appropriate manipulatives were aligned, so that the common topics could be taught on the same day and at the same time in the classroom. By examining the attitudes of students while they are in the act of using mathematics manipulatives, I hope to be able to provide teachers with information that will enable them to positively alter student attitudes towards mathematics, increase the time students spend actually doing math, and improve students' mathematics achievement and test scores.

Creative mathematics programs in Milwaukee (Ham & Walker, 1999) and Texas (Texas Education Service Center Region VI, 2006) resulted in improved attitudes towards mathematics by students, teachers, and parents. These programs were also associated with improved academic achievement by students. Yet, of the few programs found using specific manipulatives with specific activities (Meiss, 1992), I found none which correlated with state standards and were specifically designed for multigrade classrooms.

Research Design

This quasi-experimental, quantitative study used a single-group interrupted time-series design. The quasi-experimental design was chosen over the true experimental design because the participants consist of one intact group (Creswell, 2003). The participants were the students in Grades 7 and 8, in my own the seventh and eighth multigrade classroom. This is the only classroom of the school, which had seventh and eighth graders. The use of quasi-experimental design can be used when randomization is not taking place (Creswell, 2003). Randomization was not an option in this case because this was the only group of multigrade students available who could receive the treatment. Students were not randomly assigned to the experimental group, but existed, intact, in the multigrade classroom. The chosen design allows students in the multigrade classroom to be compared with themselves, as opposed to students in a different setting. A single-group of seventh- and eighth-grade students in a multigrade classroom was necessary because the treatment was a structured math program, designed for that level of multigrade students. A quantitative approach was chosen instead of a qualitative one because of the statistical procedures that could be employed on the acquired data.

Research Question and Hypotheses

The study was guided by the following research question: What impact will a structured mathematics manipulatives program have on mathematics attitudes of seventh- and eighth-grade mathematics students taught synchronously in a multigrade classroom? Self-confidence, anxiety, learning expectation, and time spent on-task completing assignments were used to measure attitudes towards mathematics (Mulhern & Rae, 1998). The hypotheses tested in this study are listed below.

H_o1: Mathematics manipulatives will have no impact on student attitudes towards mathematics success in a multigrade mathematics classroom.

H1: Mathematics manipulatives will have a positive impact on student attitudes towards mathematics success in a multigrade mathematics classroom.

H_o2: Mathematics manipulatives will have no impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

H2: Mathematics manipulatives will have a positive impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

H_o3: Mathematics manipulatives will have no impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

H3: Mathematics manipulatives will have a positive impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

H_o 4: Using mathematics manipulatives will have no impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

H 4: Using mathematics manipulatives will have a positive impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

H_o 5: Using mathematics manipulatives will neither increase nor decrease the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

H 5: Using mathematics manipulatives will increase the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

Hypotheses 1-4 will be measured using the MAS, while hypothesis 5 will be measured using the Classroom Observation Checklist.

Methodology

Population. The general population for this study is all of the seventh- and eighth-grade mathematics students in a private church school system in the southern United States. The church school system is one of eight geographic conferences administered by a protestant church union in the Southeastern United States. The geographic union is home to 203 schools, including 187 elementary schools (most of which are multigrade), 16 academies, one college, and two universities. All of these schools are fully accredited by the Accrediting Association of the church schools for the system and its colleges and universities, and are members of the National Council of Private School Accreditation. The philosophy of all schools in the division is to provide an educational program, which "fosters a balanced development of the whole person—physically, intellectually, socially, and spiritually" (Journey to Excellence, 2008, p. 5).

The multigrade school of the current study is one of the 203 schools located in the division described above. The multigrade classroom of this study is the only one in this school, with students in either Grade 7 or 8. The population of the school averages 70 students each year. All of the classes except kindergarten are multigrade. Small multigrade schools are not affiliated with large school districts and therefore do not receive funding for programs akin to the Connected Mathematics Project (Ham & Walker, 1999) or summer institutes to help teachers enhance the teaching of mathematics.

At least twice each year, the six full-time educators at the school participate in professional development activities that are planned and implemented by the local conference. During this time, the staff, along with the staff of the other 15 schools in the conference, engages in creative learning sessions. Every 3 years, these teachers attend professional development sessions with teachers from other schools throughout the Southeastern United Stated during the union-wide teacher's Convention. Every 5 years, the teachers participate in professional development with their colleagues throughout North America, for what is known as the North American Division (NAD) Teacher's Convention. During all of the above mentioned professional development meetings, multigrade teachers from the union or NAD plan and present at most of the breakout sessions. I am a state certified mathematics teacher in this school who has successfully taught mathematics with manipulatives for eleven years. I have attended these creative and well-presented professional growth opportunities for 17 years, but have never observed a presentation of a formal plan for teaching multigrade mathematics using manipulatives at one.

I taught mathematics and actively observed and collected data for the study. Materials include various independent mathematics manipulatives, as well as the *Hands-on Equations* manipulative program (Borenson, 1986). The collection of data consisted of classroom observations before and during implementation of mathematics manipulatives and a Mathematics Attitudes Survey (MAS). Students and parents completed consent forms prior to data collection.

Setting and Sample. The community. The study took place in a seventh and eighth multigrade mathematics classroom, at a small, religious, kindergarten through eighth (K-8) grade school in a fairly large city. With a metropolitan population of more than 2,000,000, the city is the fourth largest metropolis in the Southeast United States (City, 2008). The ethnic breakdown of the metropolitan area is displayed on Table 3.

Table 3

Metro and County School Ethnic Distribution

Metro Ethnic Population Distribution	Racial/ Ethnic Orientation	County Public Schools Ethnic Distribution
61.1%	Caucasian	34.17%
26. 9%	African American	27.33%
17.5%	Hispanic	31.20%
2.7%	Asian	2.6%

Note. From City website, 2008. Public domain.

While the median family income is $40,143, the per capita income is $23,157. In order to gain a better understanding of the students who comprise the case, a glance at the performance of their counterparts in the county schools follows. The sample draws, primarily, from the African American community. The African American population for the area is more than double that of the nation as a whole. Public education is provided by the county, whose schools are less diverse than the city itself. The racial and ethnic distribution of the county schools is compared to the entire metropolis in Table 3 above. As can be seen from Table 4, only one in four of the middle schools, from which the students at the school are zoned, had more than a 50% pass rate on the mathematics section of the most recent state assessment test. Although this is an improvement for this particular middle school, it is still below the county mathematics pass rate of 58% for the same period. The average grade on the state assessment test for the entire county is a “B.” Although countywide math scores have improved significantly on the state test, black students remain far behind other ethnic groups (Orange, 2008).

Table 4

Florida Comprehensive Assessment Test Scores (FCAT)

Middle School (MS)	2006 State Test Pass Rate	2007 State Test Pass Rate	2008 State Test Pass Rate
MS 1 Grade 7	31%	40%	38%
MS 1 Grade 8	45%	32%	42%
MS 2 Grade 7	29%	49%	54%
MS 2 Grade 8	43%	39%	50%
MS 3 Grade 7	28%	31%	22%
MS 3 Grade 8	32%	45%	29%
MS 4 Grade 7	40%	43%	45%
MS 4 Grade 8	44%	48%	46%

Note. From the state department of education website, 2008. Public domain.

As Table 3 reflects, the actual city population and school enrollment of African American students appears to be consistent. In light of this, it is safe to assume that if the seventh and eighth graders at school in this study were attending their zoned neighborhood middle school, their state mathematics test results would fall in the range of the scores on Table 4. The state test taken by public school students is not required for private schools. To get a picture of how the students of the current study perform, it is necessary to compare them to other students within their private school system.

The students in the current study are a part of a national private school system, which utilizes the Iowa Test of Basic Skills (ITBS) to indicate student achievement. In the October 2008 administration of the ITBS, seventh- and eighth-grade math students of the current study scored at the 44th and 22nd percentile rank respectively (Yu, 2008). These percentile ranks indicate that the students scored the same as or higher than 44% and scored the same as or higher than 22% of the seventh- and eighth-grade math students nationwide. This is below the mean percentile range of the larger population of private schools that the school is affiliated with in the United States. According to the Cognitive Genesis Report (2009), the average mean percentile of the 7,744 seventh- and eighth-grade students of the larger population is about 56 and 57 respectively.

It is clear that the seventh- and eighth-grade students at the school of the current study are not keeping pace with the seventh- and eighth- grade students in the larger private school system that they are attached to in the United States. While their classmates across the nation are improving on the ITBS, the students at this school continue to lag behind the national results. Unfortunately, the public school students in the county where the school is located are not keeping pace with the rest of the nation either. As indicated on the state assessment test above, African American students (referred to as African-American by the NAEP (2009)) in the county where this study was conducted are not improving as they are in the rest of the state where their performance in NAEP Grade 8 mathematics raised the ranking of Florida's students of that subgroup from near the bottom quarter of the 50 states to near the top third (NAEP, 2009, p. 10).

The school. In the parochial, non-profit school, all classrooms, except kindergarten, are multigrade and the student-teacher ratio averages 13-1. In fact, all of the K-8 schools in the conference system, of which the school is affiliated, are multigrade, with small student-teacher ratios. These classrooms are called multigrade because more than one grade is taught in the same room by one teacher. The majority of the students in this population are African Americans or West Indians of African descent. The school's enrollment averages 70 students each year in grades K-8. The seventh- and eighth-grade classroom, which serves the entire seventh- and eighth grade population of the school, averages between 10 and 25 students in any given school year.

The 11 students whose progress is monitored in this study are a convenience sample, since they include all of the seventh- and eighth-grade mathematics students in their school's only multigrade classroom where structured use of manipulatives is employed during the target school year. The seventh- and eighth-grade classroom is generally 90% African American and West Indians of African descent, with 10% mixed ethnicity and race. Among public school students, the percentage receiving free or reduced lunch is an indicator of family income, but no such lunch program exists in the private school that this study's sample population attends. There is, however, a tuition subsidy provided by a county agency to low income families whose children attend private schools. Nearly 63% of the families of children in the sample are on the tuition subsidy program, an additional 5% of their families qualify but have not applied for assistance.

I have been affiliated for more than seventeen years with the multigrade system described above, and am currently the teacher of the multigrade classroom for the seventh- and eighth- grade students. For this study, I served as curriculum designer, classroom manager, observer, and data collector all at once.

Instrumentation and Materials

Researchers such as Shapka and Keating (2003) and Mulhern and Rae (1998) explained that surveys based upon attitudinal scales are appropriate instruments to measure mathematics attitudes of students. When Leinenbach and Raymond (1996) examined the achievement of Algebra I students, quantitative data collection included only classroom tests; however, classroom observations informed the researchers that students enjoyed math when using manipulatives. In an attempt to understand the attitudes of multigrade students using mathematics manipulatives, this study employed two instruments to collect data on its subjects' attitudes: the Mathematics Attitudes Survey (MAS) and the Classroom Observation Checklist (both can be found in the Appendices A and B respectively). Raw data from the MAS and Classroom Observation Checklist are in a locked file cabinet in my home, where they will remain for five years.

Mathematics Attitudes Survey (MAS). MAS is based upon the Fenneman-Sherman Mathematics Attitudes Scales Short Form (FSMAS-SF) as adapted by Mulhern and Rae (1998); however not all of the scales of the FSMAS-SF are used in it. The Fennema-Sherman Mathematics Attitudes Scales (1976) were created to aid research into gender-related differences in mathematics achievement among high school students but have, since 1976, been widely used to examine attitudes towards studying mathematics and the correlates of these attitudes. According to Mulhern & Rae (1998), the full FSMAS "takes approximately 45 minutes to complete, and participants tend to lose interest as responding time goes on" (p. 296). For this reason, they constructed their condensed FSMAS-SF version of it:

> This condensation was accomplished by retaining the nine items with the highest factor structure coefficients in each of the first five factors identified and the six items with the highest factor structure coefficients in the sixth factor. Only six items were retained in the sixth factor so that only items with structure coefficients above $|.40|$ criterion would be included in the shortened version. (p. 299)

The six factors used by Mulhern and Rae (1998) on the FSMAS-SF as measures of attitudes towards math are:

1. Mathematics-Related Affect, comprised of confidence and anxiety
2. Parents Attitudes
3. Usefulness of Mathematics
4. Mathematics as a Male Domain
5. Success in Mathematics
6. Teacher Attitudes towards the child's success

The Mathematics-Related Affect Scale on the FSMAS-SF resulted from combining items from the Anxiety and Confidence scales of the original FSMAS. Each of the factors named above forms a mathematics attitude scale. Of these scales, three were used for the current study to frame the Mathematics Attitudes Survey. These three scales are:

1. Success in Mathematics
2. Mathematics Related Affect, comprised of confidence in learning mathematics and mathematics anxiety
3. Usefulness of Mathematics

As with the original FSMAS, the FSMAS-FS uses a 5-point Likert-type response format; however, only 25 items form the entire version of the shortened instrument. Scores are awarded for each of the scales, with item responses converted into numerical form by weights 5, 4, 3, 2, or 1 to each of 5 responses. Negative worded statements are inversely weighted.

Survey Reliability and Validity. "Reliability is the agreement between two efforts to measure the same trait through maximally similar methods" (Campbell & Fiske, 1959, p. 83). Reliability is described by Merriam (2002, p. 27) as the "extent to which research findings can be replicated" and yield the same results. In addition to including reliability of instrumentation, researchers can include the analysis of "reliability of documents and personal accounts…through various techniques of analysis and triangulation" (Merriam 2002, p. 27). Gravetter and Wallanau (2005) advise that an instrument is reliable if it produces measures that are stable and consistent. That is, using the same individuals under the same conditions nearly the same scores will be received each time. A strong and high correlation between two measurements renders a high reliability.

Researchers use Factor Analysis to describe "the interrelationships among a number of observed variables (Hall & Swee, 2006, p. 1). Factor analysis is useful, therefore, for providing construct factorial validity. If there is a relationship between the variables, factor analysis should reflect these relationships. Factors in the FSMAS-SF were analyzed using FACTOR AAF (principal axis factory) procedure in $SPSS_x$. "Although the absolute values of the structure coeffecients were slightly lower than those produced by the principal components solution, their rank orders were virtually identical on each factor" (Mulhern & Rae, 1998, p. 209).

Table 5 indicates the reliability coefficients for each scale on the FSMAS-SF as well as the total scale score.

Table 5

Internal Consistency Reliability Coefficients for the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) and Short-Form FSMAS (FSMAS-SF)

Name of Scale	FSMAS	FSMAS-SF
Attitude Toward Success in Mathematics	.84	.87
Confidence in Learning Mathematics	.91	
Mathematics Anxiety	.90	
Mathematics-Related Affect*		.93
Usefulness of Mathematics	.88	.88
Total Scale	.96	.93

Note. From "Development of a Shortened Form of the Fennema-Sherman Mathematics Attitudes Scales," by F. Mulhern and G. Rae, 1998, *Educational and Psychological Measurement, 58,* p.295. Reprinted with permission from the author.
*combination of Confidence in Learning Mathematics and Mathematics Anxiety.

The FSMAS-SF was the source of all statements on the MAS. Its goal is to investigate student attitudes toward mathematics. From Table 5 it is clear that the first scale, entitled Mathematics-Related Affect by Mulhern and Rae (1998) actually combines the confidence and anxiety scales of the original FSMAS. The second and third scales of the FSMAS-SF measure Usefulness of Math and Success in Math, respectively. The survey based upon FSMAS-SF is provided in the Appendix.

Alpha reliability analyses were performed on the summed scores for each scale and for the entire instrument. "Analyses were carried out using the RELIABILITY and FACTOR PA1 procedures in SPSSx" (Mulhern & Rae, 1998, p. 297). The alpha reliability for scores on the FSMAS-SF, as well as the FSMAS is reported in Table 5 (Mulhern and Rae, 1998). The results indicate high reliability for the single composite score and each of the subscale scores. Cronbach's alpha was used, providing coefficients ranging between .79 and .96.

Face validity is generally understood as a "subjective and cursory judgment of an assessment…to ascertain whether, on the face of it, it appears valid" (Mostert, 2006, p. 1). Although it is the least considered in the judgment of validity, without it no other validation can be established. The MAS completely utilizes the FSMAS-SF to measure attitudes towards mathematics, and therefore reflects "reasonable, consistent, and understandable surface connection between the instrument and test items on one hand and their underlying construct on the other" (2006, p. 3).

Content validity refers to "the degree to which a measure covers the range of meanings included within the concept" (Babbie, 1992, p. 133). The classic example used to teach validity at Walden University during the spring 2008 EDUC 8025 Quantitative course taught by Dr. Ashraf Esmail is "If you were interested in gauging students' attitudes towards History class, you may want to have a battery of questions that access different aspects of history and not one broad spectrum" (Validity and Reliability notes, p. 5). The MAS has several questions related to mathematics attitudes therefore, it can be said that the content validity exists.

Classroom Observation Checklist

The Classroom Observation Checklist was used to observe and measure the time students spent completing mathematics assignments in the classroom. While students completed assigned mathematics activities in the classroom, their time of engagement in mathematics activities was observed and recorded on the Classroom Observation Checklist (found in the Appendix B). This is interpreted as "time on-task". A systematic discussion of data collection using the checklist follows later in chapter 3.

Observation, according to Hatch (2002) allows us to "understand the culture, setting, or social phenomenon being studied from the perspectives of the participants" (p. 72) and is recommended whenever a situation can be observed firsthand (Coleman & Briggs, 2002; Merriam, 2002). The challenges to time, effort, and resources that observation entails are outweighed by its values, as enumerated by Coleman and Briggs (2002).

1. Observation gives direct access into complex social interactions and physical settings.
2. Observations provide permanent and systematic records of interactions and settings.
3. Observations can be context sensitive.
4. Observations allow triangulation and increase reliability by enriching and supplementing data gathered by other techniques.

5. The varied techniques of observation can yield different types of data (qualitative or quantitative).
6. Observations can address a variety of types of research questions.

Hatch (2002, p. 72) also identified strengths of observation that are abstracted as follows:

1. Direct observation of social phenomena permits better understanding of the contexts in which such phenomena occur.
2. Firsthand experience allows the researcher to be open to discovering inductively how the participants understand the setting.
3. The researcher has the opportunity to see things that are taken for granted by participants and would be less likely to come to the surface using other data collection techniques.
4. The researcher may learn sensitive information from being in the setting that informant may be reluctant to discuss in interviews.
5. Getting close to social phenomena allows the researcher to add his or her own experience in the setting to the analysis of what is happening.

Extending an observation instrument beyond a simple tally form renders ease of replication of the observation by other researchers. This results in a structured observation. The current study utilizes a structured observation format that enhances reliability as discussed in the next section.

Observation reliability. Coleman and Briggs (2002) suggested that the quality of the research instrument and the number of observations undertaken determine its reliability. As the number of observations increase so does the reliability. In addition, different researchers should reach similar results. Aubrey (2000) advised, "for reliability purposes two observers each must observe the same subject at the same time" (p. 60). In the current study, multigrade students were observed in the classroom six times when not using manipulatives and observed six times while using structured manipulatives to solve mathematics problems. A colleague, familiar with observational techniques and the use of mathematics manipulatives in a multigrade classroom served as an independent observer. She was briefed as to the definitions and observation of on-task and off-task classroom behaviors, and recording of each. Practice observations were held before the actual collection of data. Simultaneous observations occurred, once when manipulatives were not used and once when manipulatives were used. The simultaneous observations were compared and the concordance between compared, as discussed by Scope (2007). As students completed mathematics activities, observation of time on-task was noted on the Classroom Observation Checklist. Quantitative analysis of the Classroom Observation Checklist will be discussed later in this chapter.

Internal validity asks, "How congruent are one's findings with reality? In quantitative research this question is usually construed as, Are we observing or measuring what we think we are observing or measuring?" (Merriam, 2002, p. 25). Threats to internal validity are "experimental procedures, treatments, or experiences of the participants that threaten the researcher's ability to draw correct inferences for the data" (Creswell, 2003, p.171). Since the sample was comprised of a small number of participants, multiple sources of data and multiple investigators, as recommended by Merriam (2002, p. 25) were used to enhance internal validity. The two sources of data collection were the Classroom Observation Checklist and the Mathematics Attitudes Survey (MAS). Data on the Classroom Observation Checklist was recorded while students were observed during independent math activity time. Data on the MAS was obtained when student wrote responses about their attitudes towards math. “The use of multiple researchers also strengthens the internal validity of a study” (Merriam, 2002, p. 25) The third- and fourth-grade teacher served as a second researcher, as she also collected data on the observation checklist on two occasions.

Variables and Data Collection Procedures

The independent variables applied to the group were teaching math with the seventh- and eighth- grade textbooks only and teaching with these same textbooks while using a structured manipulatives program that had been aligned with the seventh-and eighth-grade textbooks, the math standards, and appropriate manipulatives. The following dependent variables were measured by the Mathematics Attitudes Survey (MAS): Attitudes towards success in mathematics; Mathematics-Related Affect resulting from the combination of confidence in learning mathematics and mathematics anxiety while learning mathematics; and usefulness of mathematics. The Classroom Observation Checklist was used to measure the dependent variable of time on-task during mathematics.

The study followed the guidelines stated below:

Group A: $X_1 – O_1 — O_2 — X_2 — O_1 — O_2$

Measures (O_1, and O_2) follow the treatments (X_1 and X_2) as detailed below:

1. Teach math with the textbook alone (X_1)
2. Record on-task behavior using an observation checklist (O_1)
3. Record mathematics attitudes using a survey (O_2)
4. Teach mathematics with textbook, using manipulatives correlated with objectives and guided by the teacher (X_2)
5. Record on-task behavior using an observation checklist (O_1)
6. Record mathematics attitudes using a survey (O_2)

During the first and second quarters of the school year, the teacher instructed the seventh- and eighth-grade students using the textbook alone. In the middle of the third, fourth, fifth, sixth, seventh, and eighth, weeks of marking period two, the teacher observed students solving math problems independently while using the textbooks for both grades. Observations were made using the Classroom Observation Checklist (found in the Appendix). In week six, a different teacher also observed the students while they worked. The MAS was administered before the beginning of marking period three. A detailed explanation of administration of the MAS and Classroom Observation is provided later in this chapter.

During marking period three, mathematics was taught in the seventh- and eighth-grade multigrade classroom, using textbooks along with the manipulatives that had been correlated with the standards and textbooks for each grade. In the middle of the third, fifth, sixth, and seventh weeks of marking period three, the teacher observed students working math problems independently. Because of a change in the schedule of the school, observations five and six took place on the first and second day of the eighth week of the marking period. Observations were made using the Classroom Observation Checklist (found in the Appendix). In week six, a different teacher also observed the students as they work. The Math Attitudes Survey (MAS) was administered during the first week of marking period three.

Materials included the Mathematics Attitudes Survey (MAS), Classroom Observation Checklist, various independent math manipulatives, as well as the *Hands-on Equations* manipulative program (Borenson, 1986). The MAS uses four of the scales from the Shortened Form of Fennema-Sherman Mathematics Attitudes Scales (Mulhern & Rae, 1998), while all other materials are currently available for purchase.

Quantitative research methods focus on “controlling a small number of variables to determine cause-effect relationships and/or the strength of those relationships” (Mills, 2003, p. 4). The resulting data utilizes numbers to quantify the relationships. Qualitative research, on the other hand, “uses narrative, descriptive approaches to data collection to understand the way things are and what it means from the perspectives of the research participants (2003, p. 4). Hatch (2002) encouraged the use of qualitative methods so that the participants to speak for themselves. While qualitative methods are beneficial for providing detailed descriptions of the sample and their environment (Merriam, 2002) limitations of time and resources may reduce their effectiveness.

When the research design utilizes a survey a quantitative or “numeric description of trends, attitudes, or opinions of a populations” (Creswell, 2003, p. 153) is provided. Surveys provided data which researchers can use to “describe, compare, or explain individual and societal knowledge, feelings, values, preferences, and behavior” (Fink, 2006, p. 1). Three good reasons suggested by Fink (2006) for implementing a survey are:

1. To set a policy or plan a program
2. To evaluate the effectiveness of programs to change knowledge or attitudes
3. To assist in research.

Marzano (2003) found a survey particularly useful to discover which concepts mathematics educators considered essential. When examining methods for studying and measuring mathematics curriculum implementation Huntley (2009) included several qualitative and quantitative methods as having been successful. Surveys, interviews, teacher logs, and student journals or notebooks provide information concerning quality and quantity of curriculum implementation. Huntley (2009), however, suggested, “direct classroom observation yields the most comprehensive information about quality of implementation (p.356). Burstein et al (1995) went so far as to assert that “detailed classroom observations provide the best information from which to make inferences about the curriculum students are actually studying (p. 10). The major drawback to observations is finding the specific point in time that the observation reflects the entire school year (1995). Implementing multiple data collection methods compensates for this drawback. The current study uses a combination of survey and classroom observation as quantitative methods as data collection.

Table 6 indicates which method of data collection will address each hypothesis.

Table 6

Data Collection Sequence of Design and Instrumentation

Name of Instrument	Shortened Form of Fennema-Sherman Mathematics Attitudes Scales	Classroom Observation Checklist
Type of Data	Quantitative Survey	Quantitative Observation
Concepts measured/ Hypothesis Addressed	• Success in math • Confidence in learning math • Math anxiety • Usefulness of math	On-task math time
Scores/Responses Calculated	• Numerical scores awarded by weight • Negative statements inversed	• Frequency on-task every, 2 minutes for 30 minutes • Frequencies were numerically converted for statistical analysis
Type of Reliability or Validity	• Reliability coefficient of combined scales is .93 (Mulhern & Rae, 1998) • Analysis by SPSS, Inc.	• Inter-observer reliability, discussed in chapter 4 • Multiple observations
Raw Data Availability	• Survey available in Appendix • Complete raw scores available from researcher	• Checklist in Appendix • Complete frequency results available from researcher

Collecting MAS Data

Prior to the first distribution of the survey, each student was given an Informed Consent form that was signed by each parent or guardian. All administrations of the MAS took place during math class. The survey was distributed at the beginning of the math class. The survey was distributed and collected by the math teacher, who is also the researcher. Pencils were provided and the students were not timed. The math teacher collected all of the surveys at one time, after all students had completed the survey. Students who were absent were given the survey on the first day that they returned to math class. The survey was administered to these students by the math teacher. In this manner, all students received and returned the survey during both administrations.

Classroom Observation Data

During the second marking period, mathematics was taught in the seventh- and eighth-grade classroom using the textbook alone. During the third nine-week period, mathematics was taught in the seventh- and eighth-grade classroom using a structured manipulatives program. Each set of manipulatives in the program has an accompanying activity to reinforce the standard. After the manipulative and activity were introduced, I observed the students as they completed assignments, interacted with each other, used the manipulatives, and engaged in the activity for the day. Structured observations took place in the classroom using the Classroom Observation Checklist. Every five minutes of a 28-minute period, the observer set the timer for two minutes. During the consecutive two minutes, students who consistently remained on-task received a tally mark in the "On-task" that column. Students not consistently on-task received a tally mark in the "Off-task" column on the checklist. This yielded four observations during the 28-minute period.

There were six observations during the second quarter when the teacher was not teaching with mathematics manipulatives, and six observations during the third quarter when the teacher used manipulatives. I observed the classroom at four intervals during a 28-minute independent work session, for periods of two minutes at a time. This yielded eight minutes of data on each student during each observation. A second observer observed one class session without manipulatives and one while students used manipulatives for the assessment of inter-observer reliability. Data were collected for each of the four 2-minute intervals, with five minutes between each 2-minute interval to allow for teacher circulation and answering questions. The 2-minute intervals were timed with the use of a stopwatch. A total score for the Classroom Observation Checklist was then calculated for each child by totaling the scores for the four periods. The total on-task frequencies were then subtracted from the off-task frequencies.

All manipulatives are available for purchase, should a reader of this study choose to do so. Table 7 contains a selected list of manipulatives introduced and used for instruction during the third quarter. Also in Table 7 are selected standards of the National Council for Teachers of Mathematics (NCTM) and those of the Southern Union Conference (SUC), which provides accreditation for the school of the study.

Table 7

Selected Third Quarter Manipulatives with Standards

STANDARDS	MANIPULATIVES
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC- 1.4-Understands and uses fractions and decimals; 1.6-Understands and applies ratios, proportions, averages, and percentages	Geoboard, rubber bands, wrap-ups; transparency grid sheet
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC - 1.4-Understands and uses fractions and decimals;	Calculator; blank bingo sheet; bingo chips
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC - 1.4-Understands and uses fractions and decimals	Centimeter transparency grid; Geoboard, rubber bands; wrap-ups
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC -1.6-Understands and applies ratios, proportions, averages, and percentages	Geoboards; rubber bands; pattern blocks; Interlox base ten blocks

See Appendix C for a complete correlation list of manipulatives, standards, and objectives used during MP3.

Typical of a multigrade classroom regular mathematics instruction lessons were presented to the seventh and eighth grader concurrently. Standards and objectives were taught during the first 30 minutes of the mathematics class. Independent work time followed instruction for 25 minutes. During this time, students worked on assignments alone as the teacher circulated. During the second quarter students worked with appropriate manipulatives during the independent work time.

Data Analysis

The following are the hypotheses and data analyses procedures for this research study.

H_o1: Mathematics manipulatives will have no effect on student attitudes towards mathematics success in a multigrade mathematics classroom.

H1: Mathematics manipulatives will have a positive effect attitude on student attitudes towards mathematics success in a multigrade mathematics classroom.

The data collection instrument for this hypothesis was the MAS success scale. There were eight statements related to success on the MAS. The statements are listed below:

1. I'd be proud to be the outstanding student in math
2. I'm happy to get top grades in mathematics
3. It would be really great to win a prize in mathematics
4. Being first in a mathematics competition would be a great thing
5. Being regarded as smart in mathematics would be a great thing
6. If I got the highest grade in math I'd prefer no one knew
7. It would make people like me less if I were really a good math student
8. I don't like people to think I'm smart in math

The data was analyzed using the *t* test for related samples as computed by the Statistical Package for the Social Sciences (SPSS) as instructed by Kirkpatrick and Feeney (2007). The statistical *t* test for related samples was chosen for several reasons, all of which are discussed by Gravetter and Wallnau (2005). First, the population variation is unknown. Secondly, one sample was assessed, using the survey, before and after use of the structured mathematics manipulatives. Finally, the data was collected on a Likert-type scale that can be analyzed as interval data.

By definition the "*t*-statistic is used to test hypotheses about an unknown population mean μ when the value of σ is unknown" (Gravetter & Wallnau, 2005, p. 222). The *t* test allows the researcher to gain knowledge about the unknown population through hypothesis testing. The *t* test for two related samples allows the researcher to study "a single sample of individuals…measured more than once on the same dependent variable" (2005, p. 222).

H_o2: Mathematics manipulatives will have no effect on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

H2: Mathematics manipulatives will have a positive impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

The data collection instrument for this hypothesis was the MAS confidence scale. The four statements on the MAS which comprised this scale are listed below.

1. Generally I have felt secure about attempting mathematics
2. I'm no good at math

3. For some reason even though I study, math seems unusually hard for me

4. Most subjects I can handle OK, but I have a knack of mucking up math

The data were analyzed using the *t* test for related samples for the reasons stated above.

H_o3: Mathematics manipulatives will have no impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

H3: Mathematics manipulatives will have a positive impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

The data collection instrument for this hypothesis was the MAS anxiety scale. There were five statements on the MAS to comprise this scale. These statements are listed below.

1. I usually have been at ease in math classes

2. Mathematics usually makes me feel uncomfortable and nervous

3. Mathematics makes me feel uncomfortable, restless, irritable, and impatient

4. I get a sinking feeling when I think of trying math problems

5. Mathematics makes me feel uneasy and confused

The data were analyzed using the *t* test for related samples for the reasons stated above.

H_o 4: Using mathematics manipulatives will have no impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

H 4: Using mathematics manipulatives will have a positive impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

The MAS usefulness scale was used to collect data for this hypothesis. The eight statements comprising this scale are listed below.

1. I study mathematics because I know how useful it is
2. Knowing mathematics will help me earn a living
3. Mathematics is a worthwhile and necessary subject
4. I'll need a firm master of mathematics in many ways as an adult
5. I will use mathematics in many ways as an adult
6. Mathematics is of no relevance to my life
7. Mathematics will not be important to me in daily life as an adult
8. I see mathematics as a subject I will rarely use in daily life as an adult.

The data were analyzed using the *t* test for related samples for the reasons stated above.

H_o 5: Using mathematics manipulatives will neither increase nor decrease the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

H 5: Using mathematics manipulatives will increase the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

The Classroom Observation Checklist was used to collect this data. The data were analyzed using the *t* test for related samples for the reasons stated above.

Threats to validity

"External validity threats arise" warns Creswell (2003), "when experimenters draw incorrect inferences from the sample data to other persons, other settings, and past or future situations" (p. 171). With reference to the current study, a threat to validity would be application of the results to a larger population. Readers are cautioned that by circumstance, the multigrade classroom sample is small and the results may not be relevant for larger, single grade classrooms. The reader must, also, remember that the structured math program was designed for multigrade classrooms and it, therefore would not be used in a single-grade classroom.

Another threat to validity might relate to history between participants and the teacher. Since this is a multigrade classroom, this was the second year that many of the eighth-grade students will have been with the, but the first year for the seventh graders. This relationship may or may not have affected the results. One must remember that it is always the case in the multigrade classroom, that the teacher will have at least one group for two years in a row. For this reason, application of the results to single-grade classrooms is cautioned.

Ethical Issues

During the study, I taught mathematics, as well as all other academic subjects in the seventh-, eighth-, and ninth- grade classroom and actively collected data as the researcher. Limitations related to these dual roles were presented above in the section on limitations. Students and parents were informed that mathematics manipulatives were used to assist in comprehension of mathematics this year. Consent forms were sent home for parents to sign. Parents and students were informed that while working with manipulatives is a part of the mathematics classroom procedures, students were not required to participate in the data collecting and sharing of attitudinal data. Students and parents were advised that at any point during data collection student participation could have been withdrawn by simply informing the teacher.

I took several measures to protect the rights of students in this study. First, I maintained strict confidentiality by not referring in this document to students' or any other information that might identify them. Second, I gave students the opportunity to withdraw at any time and without the requirement that they provide a reason for doing so. Third, I required informed consent as a precondition to the collection of any data. Finally, I have stored all of the data in a locked file cabinet in my home, where it will remain for up to five years.

Summary

This section described the research design of the current study. It based its Attitude results on descriptive statistics derived from student responses on the Mathematics Attitudes Survey and their on-task times as recorded on the Classroom Observation Checklist. Analysis of the data is presented in chapter 4. A discussion of findings, interpretations, and implications will follow in chapter 5.

CHAPTER 4:

RESULTS

Introduction

This quantitative quasi-experimental study was designed to examine the problem of improving the attitudes of seventh- and eighth-grade students in multigrade classrooms towards mathematics. The study was guided by the following research question: What impact will a structured mathematics manipulatives program have on mathematics attitudes of seventh- and eighth-grade mathematics students taught synchronously in a multigrade classroom? The purpose of this study was to examine the attitudes of seventh- and eighth-grade students in a multigrade mathematics classroom under two conditions: learning mathematics with the textbook only and learning mathematics with the textbook and manipulatives that have been correlated with the textbook.

The study examined the impact of augmenting instruction in the multigrade classroom using manipulatives such as Geoboards, Interlox Base Ten Blocks, and centimeter cubes that were aligned with specific objectives on mathematics attitudes of multigrade students. Daily mathematics instruction in the multigrades classroom of the study consisted of notes on the white board, PowerPoint slide presentations, and discussions from the textbooks. Following initial instruction of the objective, students were presented with a manipulative and accompanying activity to reinforce the objective. After being guided through proper use of the manipulative for the day, students completed the assignment for the day using the manipulative. If the student did not need to use the manipulative, he or she was not required to use it.

Description of the Sample

The population for this study was the seventh- and eighth-grade students in multigrade mathematics classrooms of a private church school system in the southern United States during the 2009-2010 school year. There are approximately 150 seventh- and eighth-grade students in 15 multigrade classrooms in the system associated with the school of the study. Of those 15 multigrade classrooms, one was actively engaged in structured manipulatives use. This classroom contained nine students at the beginning of the study, with two additional students enrolling in the classroom and joining the study, during the school year. During marking period two (MP2), students were taught using the mathematics textbook only. The multigrade classroom of 11 students received mathematics instruction involving the structured use of manipulatives during marking period three (MP3), while using the mathematics textbook, and various manipulatives structured for use in a multigrade classroom. These 11 students became the sample for the study.

Data Collection

The two instruments used for data collection were the Mathematics Attitudes Survey (MAS) and the Classroom Observation Checklist. What follows is a detailed discussion of how each instrument was used.

MAS

The MAS, which is derived completely from the scales of the Fennema-Sherman Mathematics Attitudes Survey-Shortened Form (Mulhern & Rae, 1998) and is used to examine attitudes of students studying mathematics, was administered in order to test hypotheses 1-4. This study employs four of the nine scales of the Fennema-Sherman shortened form. As with the original FSMAS, the FSMAS-FS uses a 5-point Likert-type response format, but only 25 items were from of the shortened instrument were used. Scores were awarded for each of the scales, with item responses converted into numerical form by weights of 2, 1, 0, -1, and -2. Negative worded statements are inversely weighted (See Appendix A for a copy of the MAS).

The MAS was administered twice, once after MP2 and again, at the end of MP3. During marking periods one and two, no manipulatives were used in the multigrade classroom. Instead, mathematics instruction included classroom notes and the textbook. The first math attitudes survey was administered on the first day of math class for MP3 January 4, 2010. At that time, nine of the ten students enrolled were present. The student who was absent was given the survey on the first regular day of math class that she returned to school. All but one student completed the survey without incident. That student was later asked to clarify which of two marks on a particular line she intended. On February 4, a new student entered the multigrade classroom. This student was given the survey on the first regular day of math class after he enrolled.

The average time that it took for students to complete the survey was 15 minutes. No student took more than 20 minutes. In order to compare survey responses before and after manipulative use, I assigned a number to each student, which was written lightly on the back of the survey prior to distribution. On a separate sheet, the student number and student name was recorded. During MP3, mathematics instruction was augmented by the structured use of manipulatives. Appropriate use of each set of manipulatives, along with activities that correlated with the objective studied took place throughout MP3.

As stated in chapter one, a limitation of this study is the fact that this is the second school year that the 4 eighth graders were in the same classroom with the same teacher. Additionally, the eighth graders were exposed to math manipulatives when in the seventh grade. This may or may not have affected the feelings of the students towards math and their responses on the MAS. If the prior relationship between the eighth graders and the teacher were an issue with their responses, it should be noted that the seven seventh graders were experiencing the teacher and classroom for the first school year.

Classroom Observation

I used the Classroom Observation Checklist was to observe and measure the time on-task students spent completing mathematics assignments in the multigrade classroom, thereby examining hypothesis 5. I observed when students completed assigned mathematics activities in the classroom and recorded on the Classroom Observation Checklist (see Appendix B) the time each had been engaged in the mathematics activities. A more detailed discussion of the Classroom Observation Checklist is found in chapter 3.

There were six observations during MP2, when manipulatives were not used. I conducted five of the observations alone and one with an independent observer. During MP3, when students were taught with manipulatives, there were six observations. I conducted five of the observations alone and one with the independent observer.

My first classroom observation was conducted on Wednesday, October 28, 2009. Prior to the beginning of math instructions for the day, the teacher initiated a discussion of various ways the students had experienced math classroom instruction. Students mentioned the following: completing worksheets; teacher at the chalkboard; textbooks; group activities; self-paced computer activities; students at the chalkboard; charts and tables; PowerPoint presentations; and math manipulation.

Students expressed that self-paced instruction without adult assistance was frustrating. Group activities and manipulations were fun. PowerPoints were informative and helpful. The students did not, as a group, share any particular preference or dislike for the rest of the methods. Following the discussion, mathematics instruction began using a PowerPoint and all students in Grades 7 and 8 received the same instruction. The topic for the day was “Adding and Subtracting Fractions.” Following instructions and guided practice from the appropriate grade textbook, students received a worksheet from the textbook covering adding and subtracting of fractions. While students completed the worksheet, I completed the Classroom Observation Checklist. If students had questions during the observation period, they were instructed to raise their hands, and the teaching assistant would come to help. During the entire 28-minute period, one student required assistance. In between observations, I roamed the classroom to check on student progress. I sat in the front of the classroom to observe.

Of the nine students observed on this day, 4 were eighth graders and 5 were seventh graders. All seventh graders remained on-task during the entire observation period. Three of the seventh graders referred to their notes while completing the assignment. As to the eighth graders, three remained on-task during the entire period, while one appeared distracted during the second and third intervals. This student seemed to be doodling at one point; however, upon closer inspection it was clear that she was pretending to write writing in the air. During the third interval, this same student slept.

I conducted the second classroom observation on Wednesday, November 4, 2009. The mathematics topic for the day was "Multiplying Fractions and Mixed Numbers." This was Day 2 of the topic. I taught the lesson with the aid of a prepared PowerPoint slide and the white board in the front of the classroom. All students in Grades 7 and 8 received the same instruction. Following instruction and guided practice from the appropriate grade textbook, students received a textbook worksheet requiring them to multiply fractions. After making sure that each student had the worksheet, scratch paper, sharpened pencils, and correct notes on the desk, I sat in the front of the classroom to observe. Although a teaching assistant was in the classroom, she did not circulate because no students raised their hands during the observation. At the end of each of the two-minute observations, I circulated for 3-5 minutes to assist if needed. A new student had entered the classroom on Monday, November 2, 2009, resulting in 10 students instead of nine being in the classroom during classroom observation one. The new student was a seventh-grade girl, so the classroom demographics included nine girls and one boy. Six of the students were seventh graders; four were eighth graders.

During the classroom observation for the day, five students remained on-task for the entire independent work session. Of these, two were eighth graders and three were seventh graders. One of the eighth graders daydreamed a bit during observation interval 2. This same student talked to a different eighth grader during interval 4. Of the seventh graders who were off-task, student number 7 went to the trashcan during interval 2 and student 8 played with her neck during interval 3. The new student bit her nails during most of interval 4.

I conducted Classroom Observation 3 on Wednesday, November 11, 2009 before manipulatives were used. The topic for the day was "Dividing Fractions and Mixed Numbers." I gave the seventh and eighth graders instructions at the same time and taught the lesson with the aid of prepared PowerPoint slides. Students took notes in their mathematics journals, then used small white boards at their desks to compute examples from the board and guided practice problems from the appropriate grade textbook. The independent classroom assignment was a textbook worksheet requiring students to divide fractions and mixed numbers. I observed the students after making sure that they all had the assignment and supplies. Demographics of the class were the same as November 4, since all students were present.

During the independent practice, five students remained on-task for the entire period. Of the two eighth graders who did not remain on-task the entire time, one went to the restroom during interval two and the other giggled during intervals one and four. While three seventh graders stayed on-task, one fidgeted the entire period. Student 8, also a seventh grader, fidgeted and daydreamed during three intervals. This was despite the fact that the teacher-researcher circulated and helped students for five minutes, after each two-minute observation.

On November 18, 2009, the third and fourth grade teacher also observed the seventh and eighth graders as they completed their classroom assignment without manipulatives. Prior to the observation, the third and fourth grade teacher had received instruction on use of the Classroom Observation Checklist and the timer used. Interrater reliability related to the independent observer is discussed in a separate section, later in this chapter.

The topic for the day was "Using the Distributive Property to Add, Subtract, and Multiply Fractions." All seventh and eighth graders received the same instruction. I taught the lesson using the large white board and students used small white boards at their desk. After instruction with students, taking notes in their mathematics journals and guided practice on the desktop white boards the students completed a textbook worksheet containing fractions, mixed numbers, and whole number problems requiring them to use the Distributive Property. The observations began after the classroom teacher double checked that all students had the assignment and supplies.

Between two-minute intervals, both teachers circulated. Demographics of the classroom remained the same as November 4, since all students were present. During the classroom observation, three students remained on-task for the entire period. Two of these students were seventh graders and one was in eighth grade. During interval one, two eighth graders and three seventh graders were on-task. The new student asked for and received paper from student 7. Student 8 played during interval 1 and 2 and seemed distracted by everything around her. Student 4 tried to talk to anyone and wrote notes. Student 6 gazed into space during interval three.

Classroom observation 5 without manipulatives took place on Wednesday, December 2, 2009 and was conducted by me. There were two related topics explored on this day. They were “Table of Values” and “Plot Data on a Coordinate Plane.” Instructions were given to both seventh and eighth graders at the same time. I taught the lesson using the white board and dry erase markers. I referred to real-life situations in order to help students grasp general concepts and the specific relationship between data, point, plot, and coordinates on a plane. Students took notes in their mathematics journals and used small white boards at their desks to compute examples and guided practice problems from appropriate grade textbook. The independent classroom assignment was a textbook worksheet requiring students to complete a table, then, plot x and y values on a coordinate plane. After making sure that all students had the assignment and supplies, I observed the students. Demographics of the class were a bit different from those of the previous observations because of an absence: eight girls, one boy; five of the group were seventh graders, four were eighth graders.

During the independent practice, four students were on-task for the entire period. All of the eighth graders worked steadily during the first two intervals. During the third interval, one eighth grader slept. All of the eighth graders worked during the fourth two-minute interval, although one student worked with her head down. All of the seventh graders but one seemed agitated during independent work time. Examples of off-task behavior by seventh graders included staring into space, playing with fingers, talking to self, and writing on arms. The only seventh grader who remained on-task the entire time worked slowly, but never deviated from the assignment. On the day of observation 5 it was necessary for the regular classroom teacher to briefly (about 7 minutes) re-teach the objective because there were so many students with questions.

Classroom observation 6 without manipulatives took place on Wednesday, December 9, 2009 and was conducted by me. The topic for the day was "Solving

Equations with Integers." Both seventh and eighth graders received instructions at the same time; however, eighth graders had an extended lesson with more examples from their textbook. I taught the lesson with the aid of a prepared PowerPoint presentation. Students took notes in their mathematics journals and used small white boards at their desks to compute examples and guided practice problems from their textbooks. The independent classroom assignment was a textbook worksheet requiring students to solve simple equations using all four mathematical operations. Each grade was given a worksheet appropriated for their grade level. After making sure that all students had the assignment and supplies, I observed the students. Demographics of the class were the same as for observation 5 with student 5 still being absent.

During the independent practice, one student, an eighth grader, remained on-task for the entire period. During the independent work time, the classroom door opened twice with students from other classes coming in to ask me questions. All of the students except one seemed distracted during independent work time. Examples of off-task behavior by students included looking around the classroom, putting head down, staring into space, going to the restroom, as well as playing with nails, fingers, hair, and hands.

I conducted the first classroom observation during manipulatives use without an independent teacher-observer. It took place on Tuesday, January 19, 2010 and classroom demographics remained the same as MP2. The mathematics topic was "Finding a Percent of a Number." The math class began with PowerPoint notes. The classroom assignment was a Geoboard activity requiring students to illustrate a specified percent of the board, and then draw the shape on a Geoboard printed on paper.

All students in grades seven and eight received the same instruction and classroom activity. Geoboards, rubber bands, and the activity sheet were distributed after all students had finished taking notes. This was the fourth day that the students were given an opportunity to work with Geoboards and rubber bands. No students had questions and all eagerly began to work.

With the exception of an occasional popped rubber band, all students worked consistently for the first 15 minutes. During the last 5 minutes, a student popped her rubber band and just sat there. When asked what was wrong she remarked, "My rubber band popped." The student in front of her gave her one and they both got back to work quickly. No one went to the restroom, got water, or left the classroom for other reasons. A student sharpened her pencil, but did so with a small sharpener at her desk. No one daydreamed or talked. Of the four, two minute intervals, all but one student was on-task every time. The student who was not on-task each time was the one who needed a rubber band and had to be given one by the student in front of her.

I conducted the second classroom observation during manipulatives use without an independent teacher-observer. It took place on Wednesday, February 3, 2010 and classroom demographics remained the same as the previous observation. The mathematics topic was finding and "Identifying Points, Lines and Rays." The math class began with a review of the previous day's notes on the definition and use of points and lines and their function in designing polygons. The classroom assignment was finding and building polygons using a Geoboard and rubber bands. The manipulative for the day was a Geoboard for each student. Students were instructed to manipulate points, lines, and polygons on the Geoboard with the rubber bands, and then draw the results on prepared worksheets 2-4 of *Dot Paper Geometry* (Lund, 1980) to turn in.

All students in grades seven and eight received the same instruction, classroom activity, and manipulatives. Geoboards, rubber bands, and the activity sheet were distributed by a student helper. Since this was the third week students had been given an opportunity to work with Geoboards and rubber bands they seemed to be very comfortable with this manipulative. Between observation intervals, 3 and 4 directions for constructing perpendicular lines and polygons were clarified because several students had questions. There were no popped rubber bands during the activity and all students but one were completely engaged. The one student who was not engaged appeared to have difficulty with perpendicular lines. After the clarification in between intervals, the student became just as engaged in the activity as the rest of the class.

I conducted the third classroom observation during manipulatives use alongside an independent classroom teacher. Interrater reliability related to the independent observer is discussed in a separate section, later in this chapter. This was the same teacher who conducted the fourth observation before manipulatives use began, during MP2. I observed from the side of the classroom while the independent observer sat in the front. It took place on Wednesday, February 10, 2010, but the classroom demographics were different from the previous observation. Due to the entrance of a new student and the absence of one student, the classroom composition was as follows: 7 girls, 2 boys; 6- seventh graders, 3- eighth graders.

The mathematics topic was “Classifying Triangles by their Angles.” During the first half of the math class, students took notes as I gave instruction on how to classify triangles using angles. Students were given opportunities to go to the board to identify triangles and angles. To complete the classroom assignment each student was provided with a Geoboard, a rubber band, and a *Dot Paper Geometry* (Lund, 1980) activity sheet page 14, which required them to build and build and classify triangles.

All students in grades seven and eight received the same instruction, classroom activity, and manipulatives. Geoboards, rubber bands, and the activity sheet were distributed by student helpers. Although students seemed comfortable using the Geoboards a few of them needed extra help to find and draw the angles. All students worked diligently, although one student talked and sang to herself during intervals one and two. During interval four, one student talked and a different student watched the clock as she worked.

I conducted the fourth classroom observation during manipulatives use. It took place on Wednesday, February 17, 2010 and all students were present. The classroom demographics were as follows: 9 girls, 2 boys; 7- seventh graders, 4- eighth graders.

The mathematics topic was "Finding Surface Area and Volume." The math class began with a review of the previous day's notes and a review of the definition of surface area and of volume. The classroom assignment was to find the surface area and volume of solid figures. The manipulative for the day was Interlox Base Ten Blocks. Students were instructed to find the surface area and volume of flats and rods with a partner, then to write the answer on the white board. "Double the Dimensions" activity sheet from *Interlox Base Ten Blocks* (Blaustein, Gasper, & Sheldon, 2003) was the assignment, but time did not allow it to be completed during the observation period.

All students in grades seven and eight received the same instruction, classroom activity, and manipulatives. The small groups were homogenous with respect to grade. A student helper distributed the base 10 blocks. This was not the first time that students had completed an assignment using base 10 blocks so they were comfortable with the manipulative. Due to the nature of the assignment, students were allowed to ask questions of their partners, but not of me, the classroom teacher, as they worked. All students were engaged and on-task for the entire work session.

I conducted the fifth classroom observation during manipulatives use. It took place on Monday, February 22, 2010 and two students were absent. The classroom demographics were as follows: 8 girls, 2 boys; 7- sixth graders, 4- eighth graders. The mathematics topic was finding "Finding Perimeter and Area." The session began with a review of how to find perimeter and area; both topics had been previously taught. The classroom assignment was to find the perimeter and area of pre-determined shapes. The manipulative for the day was Interlox Base Ten Blocks. Students were allowed to work with a partner to complete the activity sheet, "Problem of Perimeter" by *Interlox Base Ten Blocks* (Blaustein, Gasper, & Sheldon, 2003). In addition to the base ten blocks, most students used rulers to draw on paper the shapes required to complete the assignment.

All students in grades seven and eight received the same instruction, classroom activity, and manipulatives. The small groups were homogenous with respect to grade. A student helper distributed the base 10 blocks. Students were allowed to ask questions of their partners, and of me, as they worked. All students were engaged and on-task for the entire work session. During the last interval, one student sat watching her partner, instead of making her own construction with the base ten blocks. When asked why she was neither building a shape or finding the perimeter she responded that she wanted to see her partner's design before trying that particular shape. No students talked to anyone besides their partner or me, the teacher. Several students said, "Oh I *see* the difference between perimeter and area now."

I conducted the sixth classroom observation while manipulatives were in use without the presence of an additional teacher-observer. It took place on Tuesday, February 23, 2010, and two students were absent. The classroom demographics were as follows: 7 girls, and 2 boys; 6- seventh graders and 3- eighth graders. The mathematics topic was "Naming Triangles." The math class began with PowerPoint notes on how to categorize triangles by their angles as well as identifying parallel, perpendicular, and skewed lines. The classroom assignment was a worksheet, "Classifying Triangles by their Angles" (*Lund,* 1980). The manipulatives for the day were Geoboards, rubber bands, protractors, and rulers. All students in grades seven and eight received the same instruction, classroom activity, and manipulatives. Although encouraged to, only two students actually used the manipulatives to complete the activity. Students worked alone and everyone was on-task until completing the assignment.

There may be several reasons for a student failing to diligently complete the math assignment. The off-task behaviors during MP2 during textbook only use included sleeping, writing notes, sharpening pencils, going to the restroom, playing with fingers, and staring into space. Off-task behaviors when manipulatives were added to instruction during MP3 included popped rubber bands, talking and singing, head down, restroom use, and playing with fingers and hair. Some of the off-task behaviors, such as pencil sharpening or using the restroom, may have been valid. Regardless of the reason, to be consistent, all non-working behaviors were counted as off-task during classroom observations.

Interrater Reliability

As stated above, an independent observer participated in one observation during each marking period. Hatch (2002) encouraged researchers to "provide excerpts from their data to give the reader a real sense of how what was learned played out in the actual settings examined" (p. 225). This section provides a picture of the two occasions on which the independent observer joined me. During both MP2 and MP3, the independent observer sat at a desk in the front of the classroom while I sat at a separate desk. With a few exceptions, the independent observer and I recorded the same on-task and off-task behavior tallies. Details of the exceptions and reasons for the different off-task behavior tallies guide this section.

During MP2, the independent observer and I differed in our marks of students seven, eight, and ten. Student eight ran out of paper and sat playing with a mobile at her desk. Student seven gave student eight paper. The independent observer recorded the incident as three out of four off-task tallies for student seven, while recording four out of four off-task tallies for student eight. Then I counted two out of two off-task tallies for student eight and two out of four off-task tallies for student seven. After math class, we discussed the incident and agreed to record the independent observer's version as the official one. Student ten sat staring at the other students and the independent observer before getting started. I recorded zero out of four off-task tallies, while the independent observer recorded one out of four off-task behavior tallies. After math class, we agreed to count the late start, and all other late starts, as off-task behavior.

During MP3, observations recorded by the independent observer and I were the same for all but two students. Student seven talked herself through the activity. The independent observer recorded one out of four off-task behavior tallies for her, while I recorded no off-task behavior tallies for the student. Since the student never stopped working, we agreed to record two off-task behavior tallies for her. Student ten watched the clock during work time. The independent observer recorded two off-task behavior tallies and I recorded one off-task behavior tally. The official count became two off-task behavior tallies for this student.

During both MP2 and MP3, the incidences of difference between the independent observer and me related to students seven and ten. Haworth (1996) suggested that the easiest method of assessing inter-observer reliability is percentage agreement. During MP2, when textbook only was used, the independent observer recorded 62.5% of the class on-task, and while I recorded 72.5% of the class on-task. During MP3 when structured manipulatives were added, the independent observer recorded 87.5% of the class on-task, while I recorded 95% of the class on-task. The Pearson Correlation coefficient is also a popular method for assessing inter-observer reliability (Haworth, 1996). Using SPSS computer software, Pearson Correlation between the two observers for MP2 was .866. The $\rho = .001$, with 10 students. This correlation is significantly different from zero on a two-tailed test at either .05 or .01 alpha level. For MP3 the correlation equals .620, with $\rho = .056$, based on 10 students.

Several cautions by Gavetter (2005) regarding correlations seem appropriate in this case. First, the correlation does not consider the why in relationships. For example, the correlation does not reflect that student seven talks to herself as she completes assignments. This was known to me, the teacher-researcher, and I shared it with the independent observer. An additional caution by Gavetter (2005) is that a correlation can be impacted by outliers. When a subject's value is significantly different from those of other subjects, an outlier exists. The one "outlier can have a dramatic influence on the value obtained for the correlation" (Gravetter, 2005, p. 423). Table 8 shows the tallies for the two observers during both marking periods.

Table 8

Inter-rater Ratings

	MP2		MP3	
Student	Teacher-Researcher	Independent Observer	Teacher-Researcher	Independent Observer
1	2	2	4	4
2	4	4	4	4
3	2	2	3	3
4	2	2	Absent	Absent
5	4	4	4	4
6	3	3	4	4
7	2	1	4	2
8	2	0	4	3
9	4	4	4	3
10	4	3	3	2
11	Not entered	Not entered	4	4

Note. Student 11 entered the class in January.

During MP2, the independent observer and teacher-researcher recorded tallies for seven students the same and three differently. During MP3, there were eight instances of exact tallies and two that differed. Since the agreement between the observers is consistent with eight subjects during MP3, the two disagreements may be considered outliers. These outliers may have skewed the Pearson Correlation.

Data Analysis

I performed all statistical analyses for this study using SPSS for Windows version 15.0. I tested each of the five hypotheses using the Paired Samples T Test, also referred to as the related-samples *t* statistic. I compared the scores on the Classroom Observation Checklist and MAS generated during MP2, before manipulatives use, to those concurrent with manipulatives use during MP3. The results for the sample incorporate the means, standard deviations, degrees of freedom, alpha levels, and *t* values.

The *t*-statistic is ideal for testing the hypotheses about unknown population means when the value of the standard deviation is unknown (Gravetter & Wallnau, 2005). Additionally, the *t* test for two related samples gives the researcher the opportunity to examine one sample more than once using the same dependent variable. The dependent variable is mathematics attitudes of seventh- and eighth-grade students in a multigrade classroom. A more detailed discussion of reasons for using the *t* test for two related can be found in chapter 3.

I designed this study to address the question of what impact a structured mathematics manipulatives program would have on mathematics attitudes of seventh- and eighth-grade mathematics students taught synchronously in a multigrade classroom. The following section presents the statistical analysis and findings in light of each hypothesis tested. Hypotheses 1-4 were measured using the MAS. Hypothesis 5 was tested using the Classroom Observation Checklist.

On the MAS, students responded to each statement by placing an X in one of the columns labeled: "Strongly Agree," "Agree," "Neither Agree or Disagree," "Disagree," or "Strongly Disagree." To these responses, I assigned one of four possible corresponding point values: 2, 1,0,-1, or -2.... Negatively worded statements were treated as positive statements of negative values.

Hypothesis 1

Ho: Mathematics manipulatives will have no impact on students' attitudes towards mathematics success in a multigrade mathematics classroom.

Ha: Mathematics manipulatives will have a positive impact on students' attitudes towards mathematics success in a multigrade mathematics classroom.

The MAS contains eight statements dealing with attitudes towards mathematics success. The positively worded statements are:

1. I'd be proud to be the outstanding student in math.
2. I'm happy to get top grades in mathematics.
3. It would be really great to win a prize in mathematics.
4. Being first in a mathematic competition would make me pleased.
5. Being regarded as smart in mathematics would be a great thing.

The negatively worded statements are:

1. If I got the highest grade in math, I'd prefer no one knew.
2. It would make people like me less if I were really a good math student.
3. I don't like people to think I'm smart in math.

Students who see themselves as successful in math class would strongly agree with the positively worded statements, such as those describing getting top grades or winning a mathematics prize. The same students would strongly disagree with the idea of hiding good grades in mathematics class. Figure 1 is an excerpt of the MAS. It provides an example of how the MAS may have been marked and then scored, using only the success scale.

Scale and points		**Strongly agree**	**Agree**	**Neither agree or disagree**	**Disagree**	**Strongly disagree**
S+ 1	I'd be proud to be the outstanding student in math		X			
S+ 0	I'm happy to get top grades in mathematics			X		
S+ 0	It would be really great to win a prize in mathematics			X		
S+ 1	Being first in a mathematics competition would make me pleased		X			
S+ 1	Being regarded as smart in mathematics would be a great thing		X			
S- 0	If I got the highest grade in math I'd prefer no one knew			X		
S- 1	It would make people like me less if I were really a good math student				X	
S- 1 S=1	I don't like people to think I'm smart in math				X	

Figure 1.Excerpt from MAS: Success Scale with sample scores for clarification. Full MAS is in the Appendix *Note.* From "Development of a Shortened Form of the Fennema-Sherman Mathematics Attitudes Scales," by F. Mulhern and G. Rae, 1998, Reprinted with permission from the author.

The "scale and points" column is not included on the complete MAS student version, but is included here for calculation purposes. The student in Figure 1 received +3 and -2, rendering a success scale score of 1. The confidence, anxiety, and usefulness scales were marked and scored in like manner. Table 9 displays the results of all student responses on the MAS related to success for Hypothesis 1.

Table 9

Hypothesis 1: Success-Student Response Totals

Student	Textbooks Only	Textbooks with Manipulatives
101	5	11
102	14	12
103	7	9
104	8	13
105	4	9
106	2	2
107	8	16
108	8	4
109	1	10
110	2	8
111	8	8

Students worked with textbooks alone during MP2, but with the addition of structured math manipulatives during MP3. The MAS was distributed before the first math class for MP3and again at the end of MP3. I summed the student scores according to their responses on the Likert scale, as explained above, and put them into SPSS. As can be seen in Table 9, most students scored higher (nearly 64%) on the MAS success scale after using the textbook along with the structured manipulatives than after using the textbook only.

Table 10 illustrates the results of the *t* test for Hypotheses 1.

Table 10

Hypothesis 1: Success-Statistical Analysis

Mean	Standard Deviation	*T*	Df	Sig. (2-tailed)
-3.182	4.238	-2.490	10	.032

Reporting of results for the *t* test for related samples follows the format described by Gravetter and Wallnau (2005). Use of mathematics manipulatives resulted in students displaying improved attitudes towards mathematics success by an average of M = -3.182 with SD = 4.238. According to the SPSS results in the table above, the improvement was statistically significant, $t(10) = -2.49$, $p = .032$, $r^2 = 0.383$. With df of 10 standard *t* distribution table requires a *t* value of +/-2.228 for significance at α = .05. The *p* value of .032 is less than .05, rendering the obtained *t* value of -2.49 significant, so the results are significant with $\alpha = .05$. Therefore, I reject the null hypothesis in favor of the alternative hypothesis and conclude from the results, that the use of structured mathematics manipulatives had a positive impact on attitudes of some students towards mathematics success in a multigrade mathematics classroom.

The range of change in the success scale was -4 to 9. The mode consisted of three numbers, which occurred twice: 0, 5, and 6. By comparison, nearly 64% of the students experienced improved attitudes towards success while using manipulatives and around 36% of them did not. There was no change in the attitudes of two (around

18%) of the students. The same amount experienced no change in attitudes towards success. The highest score of any student on the success scale was 16, by student 107, during manipulatives use. This was an increase from a score of 8 for this student from when manipulatives were not used. In contrast, when manipulatives were not used, the lowest score of 1, by student 109, increased to 10 when manipulatives were added to the classroom. The second highest score of 14, by student 102, actually decreased to 12 during manipulatives use. This same student experienced an increase in all other scales except anxiety. On the anxiety scale, student 102 remained at 4, both before and after manipulatives use. It seems that for this student, anxiety remained low as feelings towards success in math decreased. Yet, confidence while doing math, usefulness of math, and time on-task all increased for student 102. Another student who experienced a decline in the success scale was 108. This student dropped from 8 to 4 on the success scale. The same student experienced no change in confidence and usefulness. No change on the success scale was indicated by students 106 and 111. Student 111 increased on all other scales, except confidence, which remained unchanged. Student 106 decreased on usefulness, which will be discussed in that section.

No student who experienced a decrease on the success scale decreased on any other scale. Given that students 102 and 108 increased, or remained constant on all other scales on all other attitudes scales, uncontrolled variables may have contributed to the increase. It may be that low test and quiz scores contributed to the decrease in success. Another possibility could be interaction with other students who continued to improve in math while these students did not improve as much as they might have wished. Interviews or academic records may have helped shed light on this issue, but they were not a part of during this study.

Hypothesis 2

H_o: Mathematics manipulatives will have no impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

H_a: Mathematics manipulatives will have a positive impact on the confidence of students towards learning mathematics in a multigrade mathematics classroom.

There was one positively worded statement dealing with confidence towards learning math on the MAS: Generally, I have felt secure about attempting mathematics. There were three negatively worded statements dealing with confidence towards learning mathematics:

1. I'm no good at math.
2. For some reason even though I study, math seems unusually hard for me.

Most subjects I can handle OK, but I have a knack of mucking up math.

If a student feels confident about math an X would have been placed in the strongly agree or agree columns for the positively worded statement. If the student is consistently confident when attempting mathematics an X would have been placed in the strongly disagree or disagree columns for negative statements dealing with math being hard. Table 11 displays the results of student responses on the MAS related to confidence for Hypothesis 2.

Table 11

Hypothesis 2: Confidence-Student Response Totals

Student	Textbooks Only	Textbooks with Manipulatives
101	-3	2
102	1	4
103	5	6
104	7	8
105	-5	6
106	4	5
107	6	8
108	4	4
109	-3	4
110	-3	2
111	3	3

As with the success scale, most students scored higher on the MAS confidence scale after using the textbook with manipulatives than with the textbook only. The *t* test for repeated measures was run on the confidence scale for textbook only and textbook with the use of manipulatives. Table 12 illustrates the results of the *t* test for Hypothesis 2 as rendered from SPSS.

Table 12

Hypothesis 2: Confidence-Statistical Analysis

Mean	Standard Deviation	*T*	Df	Sig. (2-tailed)
-3.273	3.438	-3.157	10	.010

Use of mathematics manipulatives resulted in students displaying improved confidence towards learning mathematics by an average of M = -3.273 with SD = -3.438. The improvement was statistically significant using a two-tailed test, t(10) = -3.157, p = .010, r2 = 0.499. With df of 10 standard t distribution table requires a t value of +/-2.764 for significance at α = .02. The t value is -3.157, so the results are significant with α = .02. Therefore, the null hypothesis is rejected in favor of the alternative hypothesis. From the results, it can be concluded that, the use of structured mathematics manipulatives had a positive impact on the confidence level of some students when learning math in a multigrade classroom.

The range of change of the confidence scale scores spanned from 0 to 11. The mode of change for this scale was 1, which occurred three times. There were two students who indicated no change in confidence, while there were no students whose confidence decreased. The students whose confidence remained the same had scores of 3 (student 111) and 4 (student 108). Whereas the success scale had a low of 1 point before manipulatives and a high of 16 after manipulatives, the confidence scale scores were considerably lower. Before manipulative the lowest confidence score was -5, while the highest score after manipulatives only reached 8. The student (number 105) who scored -5 also experienced the greatest increase of 11 points in confidence. This same student experienced the greatest increase on the anxiety scale, as well. Another noteworthy comparison between the confidence and anxiety scale scores is that student 108 indicated no change in confidence and an increase of only one point on the anxiety scale. It seems that, for some students, there may be a relationship between feelings of confidence and anxiety when doing math.

Hypothesis 3

H_o: Mathematics manipulatives will have no impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

H_a: Mathematics manipulatives will have a positive impact on the anxiety of students when learning mathematics in a multigrade mathematics classroom.

There was one positively worded statement dealing with anxiety of students while learning math on the MAS: I usually have been at ease in math classes. There were four negatively worded statements related to anxiety on the MAS:

1. Mathematics usually makes me feel uncomfortable and nervous.
2. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
3. I get a sinking feeling when I think of trying math problems.
4. Mathematics makes me feel uneasy and confused.

If a student experiences anxiety when learning mathematics an X would be expected on strongly agree with being “at ease in math class.” This same student would place an X on strongly disagree with the negative statements dealing with: feeling uncomfortable, uneasy, or having a sinking feeling when doing math. Table 13 displays the results of student responses on the MAS related to anxiety when learning mathematics.

Table 13

Hypothesis 3: Anxiety- Student Response Totals

Student	Textbooks Only	Textbooks with Manipulatives
101	-1	5
102	4	4
103	3	6
104	7	10
105	-9	4
106	7	10
107	7	8
108	3	4
109	-4	5
110	-3	1
111	1	6

Again, students were taught with the textbook alone during MP2, and manipulatives were added during MP3. All but one student scored higher on the anxiety scale when manipulatives were added than when the textbook was used alone. A higher score, in this case, means that there was less anxiety when manipulatives were used with the textbook.

Table 14 illustrates the results of the *t* test for Hypotheses 3.

Table 14

Hypothesis 3-Anxiety Statistical Analysis

Mean	Standard Deviation	*t*	df	Sig. (2-tailed)
-4364	3.828	-3.781	10	.004

Use of mathematics manipulatives resulted in students displaying decreased anxiety when learning mathematics by an average of M = -4.364 with SD = 3.82. The decrease was statistically significant using a two-tailed test, t(10) = -3.781, p = .004, r^2 = 0.588. With df of 10 standard *t* distribution table requires a *t* value of +/-3.169 for significance at α = .01. The *t* value of 3.828, so the results are significant with α = .01. Therefore, the null hypothesis is rejected in favor of the alternative hypothesis. From the results, it can be concluded that the use of structured mathematics manipulatives had a positive impact on the anxiety level of some students towards mathematics in a multigrade mathematics classroom.

The overall mode of change on the anxiety scale was three points. The range of change spanned from 0 to 13 points. There were no students who experienced an increase in anxiety after manipulatives use, yet one student indicated no change in anxiety after manipulatives use. As stated previously, this student (number 102) indicated a decrease in feelings of success towards math. This particular student may have had several negative achievement experiences, which might have contributed to anxious feelings towards success in math. Scores on the MAS indicate that student 102 experienced increased confidence and has accepted that math is useful, but anxiety prevails, even after using manipulatives. One final observation, even though student 102 felt less successful, the anxiety level remained constant as opposed to increasing.

Hypotheses 4

H_o: Using mathematics manipulatives will have no impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

H_a: Using mathematics manipulatives will have a positive impact on attitudes towards usefulness of mathematics by students in a multigrade mathematics classroom.

There were five positively worded items dealing with attitudes toward usefulness of mathematics on the MAS:

1. I study mathematics because I know how useful it is.
2. Knowing mathematics will help me earn a living.
3. Mathematics is a worthwhile and necessary subject.
4. I'll need a firm mastery of mathematics in many ways as an adult.
5. I will use mathematics in many ways as an adult.

The three negatively worded statements related to the usefulness of mathematics on the MAS were:

1. Mathematics is of no relevance to my life.
2. Mathematics will not be important to me in daily life as an adult.
3. I see mathematics as a subject I will rarely use in daily life as an adult.

In the strongly disagree column a student would place an X for the negative statements if he or she understands that math is useful in life. Table 15 displays the results of student responses on the MAS related to attitudes of the usefulness of mathematics.

Table 15

Hypothesis 4 Usefulness-Student Response Totals

Student	Textbooks Only	Textbooks with Manipulatives
101	-2	8
102	9	11
103	9	10
104	14	13
105	5	8
106	12	10
107	15	16
108	8	8
109	8	11
110	4	9
111	-3	5

All but one student scored higher on the usefulness scale when manipulatives were added, than with the textbook alone. Table 16 illustrates the results of the *t* test for Hypothesis 4.

Table 16

Hypothesis 4: Usefulness-Statistical Analysis

Mean	Standard Deviation	*T*	df	Sig. (2-tailed)
-2.727	3.690	-2.451	10	.034

Using mathematics manipulatives resulted in students displaying improved attitudes towards usefulness of mathematics by an average of M = -2.727 with S = -3.690. The improvement was statistically significant using a two-tailed test, t(10) = -2.451, p = .034, r^2 = 0.375. With df of 10 standard t distribution table requires a t value of +/-2.28 for significance at α = .05. The t value is-2.451, so the results are significant with α = .05. Therefore, the null hypothesis is rejected in favor of the alternative the hypothesis. From the results, it can be concluded that that the use of structured mathematics manipulatives had a positive impact on the attitudes of some students towards the usefulness of mathematics in a multigrade classroom.

The range of change for the usefulness of math scale spanned from -1 to 10. There were two numbers, which occurred twice: -1 and 0. Only the confidence scale reflected a lower range of change than usefulness of math. Even though there was, overall, a significant change in feelings of usefulness of math, the change levels were not as high as they could have been, in order to reflect that students saw the need for mathematics. In fact, two students, 104 and 106, felt that math was less useful after manipulatives use than before. For student 108 there was no change at all. As observed earlier, student 106 did not experience a change on the success scale. Perhaps students were not given enough opportunities in class to see the need for math in the real world. For both students, 104 and 106, the usefulness scores were fairly high to start with, 14 and 12 respectively. A follow up interview may have shed more light as to why they dropped from 13 and 10. Another concern was that student 108 experienced no change on usefulness of math (8 points) and confidence while doing math (4 points). This student actually decreased on the success scale, as discussed above. It seems that student 108 has negative feelings towards math, despite the addition of manipulatives. On the other hand, it may be that student 108 needs a more extended use of manipulatives coupled with other activities to improve the negative math feelings.

In addition to running, the *t*-statistic for individual scales of success, confidence, anxiety, and usefulness of mathematics that were identified in hypotheses 1-4 respectively, a total analysis of the MAS was conducted. Table 17 illustrates the results of the statistical analysis for the total survey. The attitudes of students improved by an average of $M = -13.545$, with $SD = 11.691$ when using manipulatives. The improvement was statistically significant using a two-tailed test, $t(10) = -3.843$, $p = .003$, $r^2 = 0.596$.

Table 17

Total Survey

Mean	Standard Deviation	*T*	Df	Sig. (2-tailed)
-13.545	11.691	-3.843	10	.003

With df of 10 standard *t* distribution table requires a *t* value of +/-3.169 for significance at α = .01. The *t* value is -3.843, so the results are significant with α = .01. No hypothesis was associated with this test but the results were rendered by SPSS.

Hypothesis 5

H_o: Using mathematics manipulatives will neither increase nor decrease the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

H_a: Using mathematics manipulatives will increase the time spent on-task during mathematics activities of students in a multigrade mathematics classroom.

Table 18 displays the student means of time spent on-task using the Classroom Observation Checklist. There were six observations when students were taught with the textbook only and six observations once the manipulatives were added.

Table 18

Hypothesis 5: Time on-task-Student Means

Student	Textbook Only	Textbook with Manipulatives
101	2.83	3.83

102	3.5	4
103	3.5	3.83
104	3	4
105	3	4
106	3.5	4
107	2.67	3.83
108	1.5	3.67
109	3.67	4
110	2.60	3.67
111	Entered MP3	4

Means were used because not every student was present for every observation. The mean of each student's time spent on-task increased during MP3 when the structured manipulatives program was used with the textbook. Student 111 did not enter the school and classroom until MP3, and was therefore not observed during MP2.

Table 19 illustrates the results of the t test for Hypothesis 5.

Table 19

Hypothesis 5: Time on Task-Statistical Analysis

Mean	Standard Deviation	*T*	df	Sig. (2-tailed)
-.91940	.56469	5.149	9	.001

As discussed in the Classroom Observation section above, there were six observations before manipulatives were used and six observations during manipulatives use, while students completed mathematics activities. The time on-task for each observation before manipulatives use was calculated and a mean derived. This mean was compared to the mean of the same student during manipulatives use. The use of mathematics manipulatives resulted in students displaying increased time spent on-task during mathematics activities by an average of M = .091940 with SD = 0.56469. The increase was statistically significant using a two-tailed test, t(9) = 5.149, $p = .001$, $r^2 = 0.726$. With df of 9 the standard t distribution table requires a t value of +/-3.250 for significance at $\alpha = .01$. The t value is 5.149, so the results are significant with $\alpha = .01$. Therefore, the null hypothesis is rejected in favor of the alternative the hypothesis. From the results, it can be concluded that seventh- and eighth-grade students in multigrade mathematics classrooms spend more time on classroom mathematics activities when using manipulatives than when manipulatives are not used.

Time on-task, through observation, is the only area that reflected no decrease and none of the scores remained the same after the addition of manipulatives to the classroom. A major difference between time on-task and the other data is that the time on-task data was actually collected while the students worked. When manipulatives were used, it was sometimes peer pressure or encouragement that kept students working, who might otherwise have remained off task. For example, on January 19 student 108 popped a rubber band, which was needed for the assignment. Student 109 provided a new one and both continued working. In some cases, once students were accustomed to working with the manipulatives they kept them on their desks but did not use them. Case in point, on February 23 the topic was angles. It was not a new topic, neither were the available manipulatives, Geoboards, new to the students. The teacher reminded the students that they could use manipulatives, but most of them chose not to. Even so, every student kept the Geoboards and rubber bands on his or her desk until they complete the assignment.

Alternative Interpretations

Annexing the use of the mathematics textbook with a structured manipulatives program may not have been the only reason that the attitudes of students towards mathematics were significantly different. Students may have been impressed with the newness of the manipulatives. Students may have been anxious to prove or apply the knowledge gained. On the other hand, students may have realized that, since they were being observed for a second marking period, it might be important to do their best. Finally, the teacher may have unknowingly displayed a more positive attitude towards mathematics when the structured manipulatives program was used.

If the newness of manipulatives affected the attitude towards mathematics, this correlates with the brain research, and was an anticipated event. The brain requires novelty and innovation to retain a concept (Caine Learning Institute, 2008). The freshness of manipulatives provided this novelty and thus justifies this point. If students were challenged to prove or apply knowledge gained this is consistent with brain based learning. The eleventh principle of Brain Learning encourages complex learning to take place in a challenging environment with reduced threat (Caine and Caine, 1990).

With every research study, the halo effect may exist. That is, the students may have determined to do their best because it would please the teacher. Alternatively, it may have been that the teacher perceived that students were more on-task when manipulatives were being used. Besides improved student behavior, Trudeau and Shephard (2010) applied the halo effect to improved teacher attitudes. The existence of an independent observer counters the impact of the halo effect on students or the teacher. In addition, students completing the survey helped to control this effect. As opposed to direct teacher observation, the students were reminded that the teacher would not know who put what for any response on the MAS. This would reduce the "desire to please" responses.

Conclusion

The purpose of this quasi-experimental study was to examine the attitudes of seventh and eighth students in a multigrade mathematics classroom under two conditions: learning mathematics with the textbook only and learning mathematics with the textbook and manipulatives that have been correlated with the textbook. Data were systematically collected and analyzed using the Paired Samples *t* test. Based on the statistical analyses, a significant difference between the attitudes of students towards mathematics when the textbooks were used and when manipulatives were used along with the textbooks. Overall, with respect to the MAS, there were four students whose attitudes towards mathematics declined on two different scales: success and usefulness. On each of the attitude scales of the MAS, at least one student reflected neither an increase nor decrease in attitudes. With the exception to the decreases and constants on the scales of the MAS stated above, a significant improvement was registered on each scale for each hypothesis. The means of the Classroom Observation Checklist indicated that an increase of time on mathematics tasks while using manipulatives.

This study posed the following research question: What impact will a structured mathematics manipulatives program have on mathematics attitudes of seventh- and eighth-grade students who are taught synchronously in a multigrade classroom? The multigrade students in this study, under the conditions described in chapter 3, experienced an improvement in attitudes when using a structured manipulatives program. Therefore, each of the five null hypotheses was rejected. A more detailed discussion of the findings, along with their implications can be found in chapter 5.

CHAPTER 5:

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Overview

This quasi-experimental study used a single-group interrupted time-series design to examine the impact that structured mathematics manipulatives might have on the attitudes of seventh and eighth grade students in a multigrade mathematics classroom. The seventh- and eighth- graders chosen for the study completed the Mathematics Attitudes Survey (MAS) twice during the school year of 2009-2010: the first administration followed MP2 when no manipulatives were used; the second administration followed MP3 when manipulatives were used. The MAS used the constructs of attitudes towards success in mathematics, confidence and anxiety while doing mathematics, and understanding the usefulness of mathematics. These four constructs are four of the nine scales on the FSMAS Shortened Form (FSMAS-SF), by Mulhern and Rae (1998). Wording for the four scales used on the MAS is exactly that of the FSMAS-SF and was used with permission. Time spent on-task while completing mathematics activities also serves as a measure of student attitudes towards mathematics. This was calculated using the Classroom Observation Checklist as students completed mathematics activities during both marking periods.

During MP2, all students in the seventh and eighth multigrade classroom were taught mathematics with the aid of the textbook, an overhead projector, PowerPoint presentations, and white boards. Manipulatives, appropriate for the objectives taught, were added during MP3. On some days of MP3, the objective was introduced simultaneously with the manipulatives, while on other days it was necessary to teach the correct use of the manipulatives separately to understand how they can be used to guide an understanding of the objective. Once the correct use of the manipulatives was illustrated, students were encouraged, but not required, to use them to complete any assignment during MP3. Specific mathematics activities used in conjunction with the manipulatives can be found in Appendix C.

I have determined through the use of surveys and observations that a structured manipulatives program positively affects student learning math in a multigrade classroom. Attitudes towards success in math and confidence while completing math assignments improved after manipulatives use. Additionally, students spent more time actively engaged in assignments during math practice time. The problem which motivated this study was low ITBS mathematics scores of some of the students in the small parochial school where I conducted the research. Although trained personnel had been hired to address the problem, it was necessary to experiment with various teaching strategies in order to meet the variety of needs of mathematics students in the multigrade classroom. Aligning manipulatives with each textbook used in the multigrade classroom and with objectives of each lesson was an option that had not been previously explored.

Inspiration for the use of manipulatives in the multigrade mathematics classroom grew out of my experience of having used manipulatives with students in multiage and multigrade mathematics classrooms for more than ten years. Many seventh- and eighth-grade students in former classes not only improved attitudes towards success and confidence while doing math but returned from high school to report successes in the

Algebra and Geometry. Conversations with my former math students from multigrade classrooms encouraged me to structure a manipulatives program that could be used by any teacher of seventh- and eighth-grade students in a multigrade classroom.

The structured manipulatives program used in the current study aligned various manipulatives, standards, and textbooks used in a seventh- and eighth-grade multigrade classroom. Although they are based on my use of a new structured math program, the findings of the current study are consistent with my observations from previous years of teaching with math manipulatives, which led me to conclude that attitudes of students regarding math generally improve when such an approach is used. Results of the current study also correlate with those at Cordova School where math anxiety decreased when manipulatives were used (Tankersley, 1993), and the fact that the students spent more time completing math assignments when using manipulatives corroborates results by Allen (2007),

Interpretation of Findings

The purpose of this study was to examine the attitudes of seventh- and eighth-grade students in a multigrade mathematics classroom while learning mathematics without manipulatives, and while learning mathematics with manipulatives. The research question addresses the impact of a structured mathematics manipulatives program on mathematics attitudes of seventh- and eighth-grade mathematics students taught synchronously in a multigrade classroom. Data from both administrations of the MAS and the twelve classroom observations—six before manipulatives and six during manipulatives use—were statistically analyzed by SPSS computer software. This rendered premanipulatives use and during-manipulatives use scores on the same group of seventh and eighth graders for the MAS and the classroom observations. The fact that each of the five null hypotheses was rejected, allowing acceptance of all of the alternative hypotheses, supports the conclusion that the use of structured manipulatives positively affected the attitudes of seventh- and eighth-grade students in the multigrade mathematics classroom that was studied.

According to MAS results, students in this classroom who used a structured math manipulatives program had a more positive attitude towards success. These results are consistent with recommendations by brain-based and learner-centered education theorists (Caine & Caine, 1990; Alexander & Murphy, 1994; Dwyer, 2002; Crick & Mcombs, 2006). According Caine and Caine (1990) of the Caine Learning Center, immersing learners in a variety of hands-on, interactive experiences is the key, in general, to academic success. Students observed in this study achieved required math objectives through manipulating objects. Such teaching is brain-friendly because it creates an environment that nurtures the emotional, physical, and social features of students (Dwyer, 2002). In a learner-centered environment, the teacher helps students feel safe and valued, while encouraging them to get along with each other (Crick & McCombs, 2006). Teachers in learner-centered classrooms implement strategies that, through the introduction of environmental enhancements such as math manipulatives, promote development of the necessary thinking and learning skills that enable students to actively engage in the learning process.

In a learner-centered classroom, students are motivated to perform in ways that conform to curriculum objectives. Although the particular academic environment may not reflect the personal goal of all students, they will perform better if they are able to perceive the environment and the teacher who designed it as supportive and encouraging. In other words, even students who prefer reading can be motivated to engage with math if the environment is helpful and stimulating. Learning of some academic subjects tends to be more affected by motivational factors than others. Learning math and physics, for example, tend to be more dependent upon students' natural ability than biology and social sciences (Alexander & Murphy, 1994). This finding, although in need of further testing, may be encouraging for the improved attitudes of students towards math. According to MAS results, students in the classroom investigated in this study, that used a structured math manipulatives program, experienced less math anxiety and were more confident about learning math than when the students were taught with the textbook only. This finding is consistent with Buehl and Alexander (2005) who found a link between students' beliefs about their academic ability and their attitudes towards learning. They observed that students who believed they could not perform were less motivated to perform and, consequently, less likely to experience academic success. Shapka and Keating (2003) found that math anxiety is related to performance. They concluded that it causes people to lose faith in their ability and, consequently, inhibits their ability to think

(p. 935). Ma and Willms (1999) also found that attitudes towards learning math are related to math performance. According to Diaz-Obando, Plasencia-Cruz, and Solano-Alvarado (2003), a student's prior experiences, as well as his beliefs about his current ability, serve an essential function in enabling him to increase his knowledge" (p. 163). In other words, negative past experience with trying or being forced to learn math are an obstacle to overcome even in the best supportive learning environment. Students will achieve more if they perceive math to be useful, and if they are confident they can learn math (Ma & Willms, 1999).

According to the results of the MAS, when students in this classroom used a structured manipulatives program, they believed that math was useful. The usefulness of math is recognizable by students when they are provided opportunities to apply concepts. Schommer-Aikens, Duell, and Hunter (2005) found that middle school students who believe that math is useful are better at problem solving. Mason and Scrivani (2002) concluded that students whose attitudes towards math increased also experienced improved problem solving skills. The students that Schommer-Aikens et al. (2005) observed had higher grade point averages when they believed math to be useful. Mason (2003) concluded that student beliefs about math are important because they lay the framework for attitudes towards math performance. Low achieving students may be "unaware of their implicit, maladaptive representations about maths….so these beliefs contribute negatively to their learning and achievement" (Mason, 2003, p. 83). Once educators identify negative attitudes, intervention can be put in place to improve achievement (Mason, 2003). Innovative instruction has been found to improve attitudes towards math performance (Mason & Scrivani, 2004). Morge (2007) concluded that students who believe that they can be successful at math might even pursue careers involving math.

According to observational data, when students used manipulatives, they spent more time on math tasks. Cummings (2000) concluded that the more time a student spends at a task, the more likely he or she is to excel at it. In a brain-friendly classroom, time on-task is meaningful and relevant for the learner. Anderson (2010) advised math teachers to use manipulatives to help students make meaning and connections between numerical and mathematical symbols, as advised by Anderson (2010). Students were instructed in the proper use and purpose of each manipulative before being allowed to work with them in class. Such instruction is consistent with Moyer (2001) who advised teachers that for manipulatives to be useful in class the purpose must be stated to students. In order for manipulatives to be meaningful for students, they must be presented in an organized manner (Spear-Swerling, 2006).

Of special note was three constructs directly related to student attitudes while performing mathematics activities: self-confidence, anxiety, and time on-task. Although time on-task displayed the highest statistical improvement, anxiety and self-confidence while doing math were second and third in that order. From these results, one can conclude that when seventh- and eighth-grade students use a structured manipulatives program in a multigrade mathematics classroom they are more confident, less anxious, and spend more time actually working on the mathematics assignments. When the treatment effect is taken into consideration, the results are even more encouraging. Gravetter and Wallnau (2005) reported that when using Cohen's r^2 to measure the treatment effect, a score above 0.25 could be considered a large effect. To obtain r^2 the following equation is used:

$$r^2 = t^2 / t^2 + df$$

Using this equation, r^2 was obtained by hand for confidence while doing math, anxiety towards math, and time on-task. While all constructs in the study received r^2 greater than 0.25, the largest were obtained by time on-task, anxiety, and self-confidence while performing mathematics activities at 0.7446, 0.5884, and 0.499 respectively. Gravetter and Wallnau (2005) observe that the r^2 value is called "the percentage of variance accounted for by the treatment" (p. 232). Therefore, in terms of treatment effect, the research question for this study can be asked: What percentage of the change in attitudes towards mathematics can be accounted for by the introduction of mathematics manipulatives into the learning process? Answers, in light of the hypotheses 2, 3, and 5, would be

Hypothesis 2 -- 49.9% of the change in attitude towards being self-confident while doing mathematics was caused by using mathematics manipulatives

Hypothesis 3 -- 58.8% of the change in attitude towards experiencing less anxiety was caused by using mathematics manipulatives

Hypothesis 5 -- 74.66% of the change in remaining on-task while completing mathematics activities was caused by using mathematics manipulatives.

It seems that the use of structured manipulatives provided the novelty and aroused the curiosity required by the brain to learn as discussed by Caine and Caine (1990). In the same vein, because the teacher taught proper use of the manipulatives as a part of the required objectives that the students had not yet been introduced to, or had not mastered, it provided a challenge for the brain. At the same time, the activities kept the students engaged, reducing time in which their attention might wander. As presented in the theoretical framework, the most significant of the 12 principles of brain-based learning for mathematics are principles six and eleven. Principal six states that the brain processes parts and wholes simultaneously. Principal 11 states that complex learning is enhanced by challenge and inhibited by threat (Caine Learning Institute, 2008).

Manipulatives allow concepts to be presented as the whole being a combination of its parts. An example of principal six (Caine Learning Institute, 2008) in action with manipulatives was the use of the base ten blocks. The flat represented a total of 100 percent because it takes 100 small blocks to make one whole flat. As the students took the flat apart and put it back together they were dissecting 100 percent and then regrouping the parts to display decimals and fractions. As students completed the accompanying assignment, they were required to use correct math terminology, symbols, and operations while using the manipulatives. Providing students with opportunities to make connections between numerical and mathematical symbols using concrete objects was recommended by Anderson (2010). This method of teaching might help students with mathematical difficulties catch up with their peers (2010).

An example of principal 11 (Caine Learning Institute, 2008), challenge without threat, happened every day of MP3 as students realized it was math time. At least two students would look at the clock and say, “Yes we get to do math now!” Regardless of the topic for the day, the classroom observation results indicated that most students participated in the manipulatives activities. The objectives did not become easier but the attitudes of the class toward completing the assignments changed. Perhaps there was what Spangler (1992) called a break in the negative attitudes towards math. The structured manipulatives program provided students the opportunity to apply objectives immediately to new situations, as recommended by Sousa (2006).

The results of this study provide teachers and administrators of multigrade environments with an additional support for a strategy that they can apply with confidence in helping help their students engage in mathematics activities. As suggested by Roberts (2002), the structured manipulatives organized the math material in a multi-sensory approach. The teacher was able to travel the 4MAT wheel (McCarthy, 2000), meeting the needs of each learning style without stress. If the students are completing the assignments without stress, they are more likely to retain the material. As students become confident in their math skills, suggests Mason (2003), they will perform math better. If students perform math better their scores on their ITBS might improve. According to the results of this study, using manipulatives both helps multigrade classroom students to believe that they can be successful and teaches them the usefulness of mathematics. When the idea that they believe mathematics to be useful is factored in, the results become important for students beyond today. Not only will students see that mathematics is necessary for completing assignments, but that it is important for life. In order for students to feel confident enough to enroll in advanced mathematics courses and use the mathematics they have learned, they must have positive math attitudes (Ma & Willms, 1999; Diaz-Obando, Plasencia-Cruz, & Solano-Alvarado, 2003; Schommer-Aikens, Duell, & Hunter, 2005)

Implications for Social Change

When students have a positive attitude towards a subject, their academic achievement improves (Alexander & Murphy, 1994; Mason, 2003; Schommer-Aiken et al., 2005). Results of observational data indicate that when students use manipulatives they spend more time on math assignments. The more constructive time a student spends on an activity, the more likely he or she will be of learning the material (Cummings, 2000; Wesson, 2010). When students learn the material it is logical that the knowledge will be reflected in successful classroom performance and on standardized tests.

As continued results of eighth grade mathematics achievement reflect, students in the United States need every opportunity available to help them succeed in mathematics (National Center for Education Statistics, 2009). The results of this study provide an additional tool for the teacher in small schools that will assist the teacher in reaching students in the multigrade learning environment. Additionally, this study may contribute to the body of knowledge, which leads to social change by encouraging teachers in multigrade classrooms to become more proactive in researching and presenting strategies that work in the multigrade classrooms.

It is no accident that mathematics progress is so closely monitored at Grades 4 and 8. At fourth grade, the student is nearly out of elementary school and eighth grade is the last year before high school mathematics. The 2007 TIMSS (National Center for Education Statistics, 2010) found eighth-grade mathematics students in the United States much improved since 2003. This positive trend must continue. Students must be proficient at algebra readiness skills before leaving middle school. Milwaukee and Southeast Texas educators (Ham & Walker, 1999; Texas Education Service Center Region VI, 2006) have implemented programs that help students comprehend and apply algebraic concepts beyond the classroom. It is vital that programs be made available to all classroom teachers that develop the necessary skills students need to comprehend, do, apply, and soar in mathematics. After all, if students believe that they cannot do math in seventh- and eighth-grade they will not do math in high school. If they do not succeed in mathematics in high school, they will not successfully compete professionally on a global scale.

If small multigrade schools are to produce students who are academically and emotionally prepared for society, they must seek out and implement state of the art programs that will make this possible. The continued theme of this study has been to improve the attitudes of students in multigrade mathematics classrooms while providing a program that is sensitive to their needs. The results of this study provide administrators and teachers in small schools with one possible program. These conclusive findings give energy to the idea of using a teaching strategy that may have been overlooked because of the lack of structure or that its cost is prohibitive. According to results of the MAS, students in this classroom who used manipulatives exhibited improved attitudes towards mathematics.

Recommendations for Action

The news from the 2009 Report Card on Mathematics (National Center for Education Statistics, 2009) is encouraging for the United States. Students in Grade Eight continue to improve in mathematics. Innovative programs such as those implemented in Milwaukee (Ham & Walker, 1999) and Texas (Texas Education Service Center, 2006) continue to result in success. These programs use learner-centered approaches to meet each student's unique needs. Among these approaches are hands on teaching activities such as the use of mathematics manipulatives. The results of this study show that manipulatives can positively affect student's attitudes toward learning math. As student attitudes toward learning improve, so will academic achievement (Alexander & Murphy, 1994; Mason, 2003; Schommer-Aiken, Duell, & Hutter, 2005). In view of these results, the addition of manipulatives in seventh- and eighth-grade multigrade classroom is advised.

The 2009 Report Card on Mathematics (National Center for Education Statistics, 2009) also indicates that the performance gap between Black and White students remains.

Additionally, only 13 states saw significant score increases for their eighth graders. The student population in this study is predominantly African American and consists of children in a state whose eighth graders did not experience a statistical increase in mathematics scores in 2009. It is clear that more needs to be done to reach the seventh and eighth graders in all schools, especially those whose populations continue to struggle to compete academically. Administrators, teachers, and school boards should read the results of this study and find the necessary resources to implement structured mathematics manipulatives programs in their multigrade schools. Teachers in seventh- and eighth-grade multigrade classrooms should particularly pay attention to this study because in addition to the successful results it demonstrates regarding attitude and time on-task, it contains an outline of appropriate manipulatives, already correlated with seventh-and eighth-grade mathematics objectives and textbooks, which can be found in Appendix C.

The results of this can be effectively presented as a PowerPoint to school stakeholders. As multigrade classrooms are usually found in small schools and small school systems, the presentation could be made at a local parent or school board meeting, to which all stakeholders are invited. The cost factor for implementation of a structured manipulatives program should be included in the presentation with a budget request for all of the necessary manipulatives for the entire school year. The results of this study could also be made available during teacher in-service opportunities and accompanied by demonstration in break-out sessions of some of the manipulatives for particular objectives.

More than 70 years ago, the leader of the national organization which certifies the teachers at the school this study was conducted implored all of its educators to "perfect [our] methods, to increase our power, to deepen our convictions, to widen our vision, to increase our devotion" (Spicer, 1937, p. 5). It is time for students in multigrade classrooms to be instructed according to methods that have been perfected just for their special situation so that one day, they can confidently compete in the society at large.

Recommendations for Further Study

This study examined the impact of manipulatives on math attitudes of seventh- and eighth-grade students in a multigrade classroom. Scores on the survey and observational data of this study affirm previous studies, which indicated the viability and impact of adding manipulatives to the mathematics classroom (Allen, 2007); Burns & Humphreys, 1990; Leinenbach & Raymond, 1996; Spear-Swerling, 2006; Tankersley, 1993).. This study indicates a positive effect of manipulatives on attitudes. Previous research concluded that improved attitudes improve learning (Alexander & Murphy, 1994; Mason, 2003, Schommer-Aikins, Duell, & Hutter, 2005). In view of the limited statistically significant data related to manipulatives, attitudes, and achievement in multigrade classrooms future research is necessary. A list of recommendations follows.

Recommendation 1: Even though "multigrade" has been used to describe the classroom of this study, it could just as easily be called a combination classroom because it is only comprised of two grades. Most schools in the system that the school of this study is affiliated with have two or more grades in the classroom. An investigation into the use of structured manipulatives in multigrade classrooms that have more than two grades would be most beneficial for these students and teachers. This would require the correlation of each of the mathematics textbooks used in the classroom, the state objectives or school system standards, and the appropriate manipulatives.

Recommendation 2: A future study could be done, implementing a math attitudes survey on students before instruction began, with or without the use of a structured manipulatives program.

Recommendation 3: An investigation could be done, comparing the use of a structured manipulatives program with three groups: seventh- and eighth-grade students in a multigrade classroom; a single grade classroom of seventh graders; and a single grade classroom of eighth graders.

Recommendation 4: This study only examined the relationship between math attitudes and structured manipulatives use. Further research could be conducted to examine attitudes and achievement, before and after implementing a structured manipulatives program.

Recommendation 5: This study examined the impact of manipulatives that had been aligned with objectives and textbooks for use in a seventh- and eighth-grade classroom. Further study might be carried out to examine the impact of manipulatives that were not aligned with textbooks and objectives. In such a study, math would not be taught synchronously to seventh- and eighth graders.

Spear-Swerling (2006) cautions educators against unstructured use of manipulatives for fear that students would consider them toys. Having taught with manipulatives for more than 10 years in single grade and multigrade classrooms, I recommend that instructors be comfortable teaching in a multigrade classroom and learn proper use of manipulatives before administering such a program for teaching or research purposes.

Conclusion

Learner-centered and brain-based learning theories encourage educators to put the learner in the forefront of the education process. The surveys and observations conducted in this study, suggest that students' attitudes toward math and time on-task improved significantly when a structured math manipulatives program was used. They also indicate that students felt less math anxiety and viewed math as being more useful after having worked with math manipulatives. What is finally important is that once attitudes are improved, students become more likely to improve academically (Alexander & Murphy, 1994; Mason, 2003; Schommer-Aiken, Duell, & Hutter, 2005).

Moore (1976) suggested that the greatest advantage of the multigrade and multi-age classrooms is the opportunity to learn in a non-threatening family setting. Miller (1991) observed that students in multigrade classrooms develop closeness beyond the school walls. While organizing and facilitating a supportive environment in the classroom, the multigrade classroom teacher must do everything possible to guarantee that students, even those with a history of being distracted and unmotivated, are given every opportunity to succeed. The results of this study suggest that a structured math manipulatives program can offer just such an opportunity for students during math time

If students in small schools are going to be prepared to be successful in college and in life, it is imperative that attitudes toward math improve. Once this takes place, it is possible that comprehension may follow. Classroom teachers, administrators, and curriculum developers at small schools are advised to take note of the results of the current study, and those of other creative programs (MUSE, 2010) that have been designed especially to enhance learning in the multigrade classroom.

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APPENDIXES

Appendix A: Multigrade Mathematics Attitudes Survey*

Thank you for taking the time to complete this short survey. The purpose of this survey is to better understand how you feel about math. Please DO NOT put your name anywhere on the survey. Once you have completed the survey please sit quietly until your teacher has collected all surveys.

PART I-Information about you and your classroom

Please circle the most appropriate response.

1. What is your gender?
2. Male   Female
3. What is your MATHEMATICS CLASSROOM type?
4. 5/6   7/8   5th only   6th only   seventh only   eighth only
5. What is your GRADE?
6. 5th   6th   seventh   eighth

.

*Adapted from "Fennema-Sherman Mathematics Attitudes Survey-Shortened Form" by Mulhern-Rae (1998). Adapted with Permission.

PART II- How you feel about Math

Directions: Indicate how you feel about each item by placing an "X" in the most appropriate blank.

Scale*		Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
C+	Generally I have felt secure about attempting mathematics					
C-	I'm no good at math					
C-	For some reason even though I study, math seems unusually hard for me					
C-	Most subjects I can handle OK, but I have a knack of mucking up math					
A+	I usually have been at ease in math classes					
A-	Mathematics usually makes me feel uncomfortable and nervous					
A-	Mathematics makes me feel uncomfortable, restless, irritable, and impatient					
A-	I get a sinking feeling when I think of trying math problems					
A-	Mathematics makes me feel uneasy and confused					
U+	I study mathematics because I know how useful it is					
U+	Knowing mathematics will help me earn a living					
U+	Mathematics is a worthwhile and necessary subject					
U+	I'll need a firm mastery of mathematics in many ways as an adult					
U+	I will use mathematics in many ways as an adult					
U-	Mathematics is of no relevance to my life					
U-	Mathematics will not be important to me in daily life as an adult					
U-	I see mathematics as a subject I will rarely use in daily life as an adult					
S+	I'd be proud to be the outstanding student in math					
S+	I'm happy to get top grades in mathematics					
S+	It would be really great to win a prize in mathematics					
S+	Being first in a mathematics competition would make me pleased					
S+	Being regarded as smart in mathematics would be a great thing					
S-	If I got the highest grade in math I'd prefer no one knew					
S-	It would make people like me less if I were really a good math student					
S-	I don't like people to think I'm smart in math					

*The scale column is excluded from the student copy

Thank you for responding to each question. Please place the survey in the envelope provided and give it to your teacher.

Appendix B: Classroom Observation Checklist, condensed

Location: ______________________________ Date: _______________________ Time: ______

Directions: Every five minutes of a 28-minute period the observer will set the timer for two minutes. During the consecutive two minutes, students who consistently remain on-task will receive a tally mark in that column. Students who are not consistently on-task will receive a tally mark in the off-task column on the check list.

Student 4

Two Minute Intervals	On-Task	Off-Task
1		
2		
3		
4		
Totals		

Comments:

Student 3

Two Minute Intervals	On-Task	Off-Task
1		
2		
3		
4		
Totals		

Comments:

Student 2

Two Minute Intervals	On-Task	Off-Task
1		
2		
3		
4		
Totals		

Comments:

Student 7

Two Minute Intervals	On-Task	Off-Task
1		
2		
3		
4		
Totals		

Comments:

Student 8

Two Minute Intervals	On-Task	Off-Task
1		
2		
3		
4		
Totals		

Comments:

Student 9

Two Minute Intervals	On-Task	Off-Task
1		
2		
3		
4		
Totals		

Comments:

Appendix C: MP3 Manipulatives Aligned with Standards

Standards: National Council of Teachers of Mathematics (NCTM)/ Southern Union Conference (SUC)	Instructional Objectives	Skills/ Assignments	Manipulatives	Activity Sources
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC- 1.4- Understands and uses fractions and decimals; 1.6- Understands and applies ratios, proportions, averages, and percentages	Use percents appropriately and effectively in problem situations Represent fractions using area models	Sense or nonsense Explorations 1 & 2	GEOBOARD, RIUBBER BAND, WRAP-UPS	Burns, M. & Humphreys (1998, pp. 139) C. A Collection of Math Lessons from Grades 6 through 8 Fulton, B. & Lombard, B. (1996) Math Discoveries About Fractions & Decimals: Grades 7-8 with manipulatives
Same as above	Recognize and build polygons	Explorations 3 & 4 Geometry Wrap-ups and Log	GEOBOARD, RIUBBER BAND, GEOMETRY WRAP-UPS	Fulton, B. & Lombard, B. (1996) Math Discoveries About Fractions & Decimals: Grades 7-8 with manipulatives
Same as above	Represent percentages pictorially Find multiple solutions to problem	Exploration 5 with a partner	GEOBOARD, RIUBBER BANDS, WRAP-UPS	Thornton, C. & Lowe-Parrino, G. (2004, p. 7) Hands-On Teaching Strategies Hands-On Teaching Strategies Fulton, B. & Lombard, B. (1996) Math Discoveries About Fractions & Decimals: Grades 7-8 with manipulatives
Same as above	Represents decimals using area models	Complete % model using transparency centimeter grid	CENTIMETER TRANSPARENCY GRID	Burns, M. & Humphreys, C. (1998, pp. 146-143)

Standards: NCTM/SUC	Instructional Objectives	Skills/ Assignments	Manipulatives	Activity Sources
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC- 1.4-Understands and uses fractions and decimals; 1.6-Understands and applies ratios, proportions, averages, and percentages	Find multiple solutions to problems Represent percentages pictorially	Explorations 9 and 10	GEOBOARDS, RUBBER BANDS, PATTERN BLOCKS	Fulton, B. & Lombard, B. (1996) *Math Discoveries About Fractions & Decimals: Grades 7-8 with manipulatives* Thornton, C. & Lowe-Parrino, G. (2004, p. 7) Hands-On Teaching Strategies
Same as above	Compare fractions, decimals, & % Use large & small % Estimate % of a number	Exploration 11 with a partner	GEOBOARD, RUBBER BANDS, WRAP-UPS	Fulton, B. & Lombard, B. (1996) Fulton, B. & Lombard, B. (1996)
Same as above	Solve equations with % Find % Use the % equation	Explorations 19 & 20	GEOBOARD, RUBBER BANDS,	Fulton, B. & Lombard, B. (1996) Fulton, B. & Lombard, B. (1996)
Same as above	Find % Use the % equation Estimate % spatially Use % to compute costs	"Paving Places"	INTERLOX BASE TEN BLOCKS	Blaustein, Gasper, & Sheldon (2003, p. 53) *Interlox Base Ten Blocks*
Same as above	Find % interest Convert Fractions to %	Exploration 21	CENTIMETER CUBES:4-5colors totaling 100 per bag…1 bag per group	Fulton, B. & Lombard, B. (1996)

Standards: NCTM/SUC	Instructional Objectives	Skills/ Assignments	Manipulatives	Activity Sources
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC- 1.4- Understands and uses fractions and decimals; 1.6- Understands and applies ratios, proportions, averages, and percentages	Find parallel segments Find perpendicular segments	DPG 2-Numeral Polygon DPG 3-Parallell Line DPG 4-Perpendicular Lines DPG 5-Constructing Polygons	GEOBOARD, RUBBER BANDS	Lund, C. (1980) *Dot Paper Geometry*
NCTM-Work flexibly with fractions, decimals, and percents to solve problems SUC- 1.4; 1.6	Identify, make, and compare Points, Lines, and Planes Classify triangles	DPG 13-Classify triangles by the sides DPG 14-Classify triangles by their angles DPG 15-Classify Quadrilaterals Lines	GEOBOARD, RUBBER BANDS	Lund, C. (1980) *Dot Paper Geometry*
NCTM- Problem Solving, Communication, Reasoning, Connections, Geometry SUC- 3.5 Classifies, draws, and measures lines and angles.	Estimate Area Apply knowledge finding area of Polygons Find the area of Irregular Shapes	Approximating Area	INTERLOCKING BASE TEN BLOCKS	Blaustein, Gasper, & Sheldon (2003, pp. 40-41) *Interlox Base Ten Blocks*
Same as above	Recognize how the compactness of a shape affects its perimeter Identify and name Polygons	"A Problem of Perimeter" Take Notes on Polygons	INTERLOCKING BASE TEN BLOCKS	Blaustein, Gasper, & Sheldon (2003, pp. 42-43) *Interlox Base Ten Blocks*

Standards: NCTM/SUC	Instructional Objectives	Skills/ Assignments	Manipulatives	Activity Sources
NCTM- Problem Solving, Communication, Reasoning, Connections, Geometry SUC- 3.5 Classifies, draws, and measures lines and angles. Florida- 8.G.2 Analyze two- and three-dimensional figures by using distance and angle	Increase spatial visualization skills Determine and compare volume and surface area Predict the volume and surface of a "doubled" structure	"Double the Dimensions"	INTERLOCKING BASE TEN BLOCKS	Blaustein, Gasper, & Sheldon (2003, pp. 50-51) *Interlox Base Ten Blocks*
Same as above	Classify shapes	Tangram Explorations, Job Cards 7-20	TANGRAMS	*Primary jobcards: Puzzles with Tangrams* (1988) Creative Publications
Same as above	-Find area of Triangles -Find area of Polygons	DPG 33-Area of Right Triangle DPG 35-Area of Polygons—Chop Strategy	GEOBOARDS	Lund, C. (1980) *Dot Paper Geometry*
Same as above	-Find area of Polygons -Determine and describe patterns in sums of angle measures of triangles and quadrilaterals	DPG 36-Area of Polygons "Draw and See"	GEOBOARDS; ANGLE RULER	Lund, C. (1980) *Dot Paper Geometry* Thornton, C. & Lowe-Parrino, G. (2004, p. 7) Hands-On Teaching Strategies
Same as above	Find the area of selected shapes Determine the angle measures of selected shapes	Take Notes on area of Parallelogram; "What's Your Angle?"	PATTERN BLOCKS	Thornton, C. & Lowe-Parrino, G. (2004, pp 5-6) *Hands-On Teaching Strategies*

Appendix D: FSMAS-SF Permission

E-Mail Strand for permission to use Shortened Version of Fennema-Sherman Math Attitudes Scales:
Hello Dr. Rae,

My name is Betty Nugent and I am a doctoral student at Walden University, USA. My research is seeking to determine the impact of a structured math manipulatives program on the attitudes and achievement of students in a seventh and eighth multigrade (12-14 year olds) classroom.

One part of the study seeks the attitudes of multigrade students towards math. Due to the young age of the students your shortened version of the Fennema-Sherman Mattitudes Sales seems to be most appropriate for this purpose. Do I have permission to use your shortened version? If so, what are the stipulations for use?
Thank you for your consideration of this request.

Betty F. Nugent
Reply Forward

Reply |Gordon Rae to me show details
Feb 16 Reply

Dear Betty,

As far as I am concerned you are free to use our shortened version of the F-S Maths attitudes scales without any conditions attached. You may, wish of course, to revert back to the original American terms in some cases.

Best wishes with the project,
Gordon

- Show quoted text -
----- Original Message -----
From: Betty Nugent
To: g.rae@ulster.ac.uk
Sent: Sunday, February 15, 2009 1:00 PM
Subject: Shortened F-S Math Attitudes Scales

Appendix E: Class Averages Permission

E-Mail Strand for permission to use class averages:
From: Betty Nugent [betty.nugent@waldenu.edu]
Sent: Sunday, March 21, 2010 8:44 PM
To: Marylin Leinenbach
Subject: hands on math results

Hello Dr. Leinenbach,

Congratulations on your continued success with inspiring students to learn (and teachers as they teach) mathematics.

My dissertation topic deals with the impact of various mathematics manipulatives on attitudes of students in multi-grade classrooms. Within the paper I would like to include a table of the results of the class averages of your students during the second nine weeks of the 1994-95 school year when manipulatives were used. Do I have your permission to include this information?

Thank you for considering this request.

Betty F. Nugent

Subject: RE: hands on math results
Date: Mon, Mar 22, 2010 07:03 AM CDT
From: Marylin Leinenbach <Marylin.Leinenbach@indstate.edu>
To: Betty Nugent <betty.nugent@waldenu.edu>

Betty,

Yes, you have my permission. Good luck on your dissertation.

Dr. Marylin Leinenbach
Associate Professor
Elementary, Early, and Special Education
Indiana State University
marylin.leinenbach@indstate.edu
812-237-2847

CURRICULUM VITAE

Betty Faye Jenkins Nugent
1326 Tindaro Dr.
Apopka, FL; bettyfnugent@gmail.com

EDUCATION

Date	Degree of Course	Institution
1975-1977	History, Pre-Law	Bethune-Cookman College Daytona Beach, FL
1979	Bachelor of Science in Behavioral Sciences/Sociology	Southern Adventist University
1986	Master of Arts in Educational Psychology	Andrews University College of Education and Psychology
2010 (projected)	Doctor of Education in Teacher Leadership	Walden University College of Education

EXPERIENCE

Date	Title	Institution
1984-1991	Math and Social Studies Teacher	Middle and High Schools Duval & Pinellas Counties in FL
1991-2000	Teacher	Orlando Junior Academy, FL
2000-2004	Teacher, Interim Principal	Mt. Sinai Jr. Academy Orlando, FL
2003- 2009	Teacher: Social Studies/History, English, Math, and AE21 (Distance)	Forest Lake Academy Apopka, FL
2005-present	History Teacher	Florida Hospital College of Health Sciences
2008-present	Vice-principal	Mt. Sinai Jr. Academy Orlando, FL

LICENSURE AND CERTIFICATION

2011 Expiration- Florida Educator Professional Certificate: History-6-12, Mathematics-5-9, and Social Science-5-9

2011 Expiration- Seventh-day Adventist Professional Teacher Certificate: Soc. Studies, English, Jr. Academy Math, Bible