Summer Stars® Math Texas Edition Research-Base

The purpose of this document is to outline and overview the research-base of *Summer Stars® Math*, a complete hands-on mathematics program specifically designed for summer learning. ETA/Cuisenaire has a long history of designing and developing manipulative-based learning programs based on solid research that demonstrates an increase in student engagement and performance. There are three research documents enclosed which outline the research base of *Summer Stars Math* and are highlighted and summarized within this letter.

Alignment to NCTM Standards and TEKS

Summer Stars Math Texas Edition is aligned to both the NCTM Standards and to the Texas Essential Knowledge and Skills. Within the program, lessons and activities are clearly organized and identified with the related TEKS Objectives to ensure instructional integrity and focus.

Hands-On Math Instruction – Time-Tested Approach for Student Success

This enclosed white paper highlights the research base for manipulative-based instruction in mathematics and describes how the ETA/Cuisenaire product development philosophy aligns to this research. *Summer Stars Math* is featured in this research document as this program is grounded in hands-on learning and incorporates "best practices" in intervention instruction. Below is an excerpt and related research from this white paper.

> *Summer Stars Math* is a program that can be used to scaffold learning for struggling students. The use of manipulative-based activities has been cited as "significant and effective" when used in math interventions, and in fact using manipulatives in intervention is recommended not only in the early grades, but also the middle grades *(Institute of Education Sciences 2009 report on RTI)*

Manipulative Use and Understanding in Mathematics

This enclosed white paper provides a history of research that supports hands-on instruction in mathematics. The document stresses the importance of students' having experiences working with concrete tools (manipulatives), representational models (sketches) and abstract notation (traditional written mathematics); this combination of experiences is critical to student learning success. Each lesson in *Summer Stars Math* is designed to support this progression, moving students through all three phases to increase understanding and retention. Below is an excerpt from this white paper that supports the instructional philosophy of *Summer Stars Math*.

> Miller and Mercer (1993) investigated the effects of three different phases of instruction—concrete, semiconcrete, and abstract—on the computational skills of LD students. In the concrete phase, concepts were introduced using concrete manipulatives. The semiconcrete phase involved practice with pictorial representations of the objects. The abstract phase presented students with abstract symbols (e.g. numbers) only. Students instructed in this manner demonstrated marked improvement in the acquisition and retention of concepts.

Dissertation – Preparing Eighth-Grade Students for Algebra in the Ninth Grade
This dissertation, developed by Julia Danielly for the Fischler School of Education and Human Services, presented a study to increase math knowledge and improve readiness of middle grades students for high school content. The instructional system used in this research study included VersaTiles® Math, an ETA/Cuisenaire independent practice system that is incorporated within every lesson in *Summer Stars Math*. The study's results illustrated an improvement in students meeting or exceeding state standards in math, as measured by the Criterion Referenced Competency Test (CRCT), from 52% a year earlier to 72%. Below are excerpts from this dissertation.

> [VersaTiles Math] is self-corrected and self-guided, in which lessons are grade explicit. In a review of this program, Ball (1999) noted that students who utilized this program in their school enjoyed the materials as they reinforced skills through practice in a multiple-choice format. She further stated that the program allows students to take ownership of their learning by maintaining a progression chart.
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> Findings from this study indicated that students learn by being actively engaged. The most effective strategies noted by participating teachers were the use of cooperative learning and VersaTiles Math Lab.

Summer Stars Math Evidence of Effectiveness
Anne Arundel County School District in Annapolis, Maryland piloted *Summer Stars Math* in 2009. The goal of the pilot was to track the effectiveness of Summer Stars Math on student achievement during their summer term. Pretests were administered at the beginning of their summer term to determine baseline performance. Posttests were administered at the end of the summer term to gauge student growth. Based on the data (which demonstrated significant student growth), Anne Arundel County School District has recommended that Summer Stars Math be implemented extensively in their 2010 summer classes. The performance data collected by Anne Arundel County in 2009 is in the process of being formatted and provided to ETA/Cuisenaire.

Hands-On Math Instruction –
Time-Tested Approach for Student Success

Walk into any high performing elementary classroom across the country during math time instruction and you will see children actively involved in the lesson...using hands-on materials to count, sort, measure, connect, and more. As commonplace in most classrooms now as textbooks, hands-on materials --or math manipulatives-- are important educational tools: tangible objects that can be seen, touched, "manipulated" by students to introduce and/or reinforce mathematical concepts. And while math manipulatives alone are not new, educators are finding (and researching is confirming) that hands-on materials can make an even greater impact on student achievement when used consistently and strategically as part of an overall approach to teaching math.

Not Just for Elementary School Anymore

Long favored by elementary teachers as effective way to teach young students, hands-on math instruction:

1. Engages learners,
2. Develops interest in mathematics, and
3. Builds understanding of basic concepts and operations.

By providing concrete experiences that bridge to abstract understanding, this approach to math instruction accomplishes the teacher's ultimate goal. One can almost see the light go off in a young student's head when they re-group base ten units into a rod and then ten rods into a flat to make 100! But hands-on math is not just for elementary schools anymore and such "a-ha" moments are being experienced in middle schools and high schools throughout the world. For decades the National Council of Teachers of Mathematics has endorsed the use of hands-on materials at all grade levels. Learning theory also supports a manipulative-based approach to math instruction by asserting that children can only begin to understand abstract concepts after experiencing them on a concrete level (Piaget, 1952). Numerous studies concur, showing that mathematics achievement increases when the curriculum includes the use of hands-on educational aids (Canny, 1984; Clements and Battista, 1990; Clements, 1999; Dienes, 1960; Driscoll, 1981; Fennema, 1972; Skemp, 1987; Sugiyama, 1987; Suydam, 1984). What's more, evidence from researchers in the past 10-20 years has proven that simply relying only on drills, workbooks, and rote memorization is an "outdated and ineffective" (Cain --Caston 1996, 271) approach for the diverse learners found in today's schools. It is no surprise to see more teachers, school districts, and states advocating – even mandating -- a hands-on math curriculum.

Cubes and Rods and Blocks, But Why?

Remember the classroom we walked into... where students were found actively engaged in learning by doing? Look around that same classroom, and you will find students with a range of learning styles and abilities, some who may be more kinesthetic or tactile, some who are more auditory or visual. The importance of differentiating instruction to reach all of these students is widely accepted and a hands-on

Even students acknowledge the difference it makes when manipulatives are incorporated into a lesson: Over three-fourths of a group of students in a NCTM study reported having stated that the use of manipulatives was helpful in learning new mathematical concepts (Stuart, 2000).

approach is proven to be engaging and appealing to all. In addition, the importance of sparking interest and excitement about mathematics cannot be overstated. Using a hands-on approach has been proven to keep students interested and long-term interest in math translates into increased ability (Sutton and Krueger, 2002).

It is critical to note however that the presence of manipulatives alone does not necessarily impact student achievement. Any tool, be it a jackhammer or a pattern block, needs to be used appropriately for best results. Manipulatives are not meant to stand alone, rather to be incorporated into a curriculum that includes experiential learning , discussion, abstraction and connection. As part of such a curriculum and with constant support from the teacher, ultimately hands-on experiences allow students to bridge concrete experiences to abstract understanding (Heddens, 1986; Reisman, 1982; Ross and Kurtz, 1993). Instructional materials and training resources for manipulatives should be made available to teachers despite their level of experience so that a hands-on approach can be implemented effectively. .

From Toys to Tools...The Evolution of Hands-On Math

An industry leader in educational supplements, ETA/Cuisenaire believes in the power of a hands-on approach to math. With a long history of supplying manipulatives such as Cuisenaire® Rods and Algeblocks® to schools, the company has seen firsthand how the role of hands-on materials in the classroom has evolved. Over thirty years ago, the company realized that furnishing classrooms with hands-on materials alone was not enough. In order for manipulatives to be considered more than "toys", in order to profoundly impact student achievement, teachers needed additional support in using these hands-on tools. With the introduction of Veri-Tech (now known as VersaTiles) in the early 1970's, ETA/Cuisenaire answered the call. The company began developing hands-on programs that include not only manipulatives but also standards-based lessons. What's more, the company includes instructional support and training for teachers so that they can implement the programs effectively in the classroom. Based on the success of such programs as VersaTiles, ETA/Cuisenaire is continuing to innovate and bring new and better hands-on math programs to educators, backed by practical experience and current research that hands-on math instruction leads not only to higher test scores, but also provides students with a true understanding and deeper appreciation of math.

Coming of Age: Hands-On History to the Latest Research

The use of manipulatives to understand mathematical concepts is not new. Ancient civilizations such as the Mayans and the Aztecs were using a variety of materials such as corn strung on wire and stretched across a wooden frame to act as counting devices: This even centuries earlier than the advent of the Chinese abacus. The first true manipulatives, maneuverable objects specifically designed for teaching, were introduced in Germany by Friedrich Froebel who began using hands-on materials to help his kindergarten students recognize geometric patterns and forms in nature. Following in Froebel's footsteps was Maria Montessori, the Italian-born educator who in the early 1900's designed a variety of wooden objects to help preschool and elementary students learn basic math.

In the middle of the 20th century the discovery of the first hands-on system, Cuisenaire Rods, was made in a small village in Belgium. There, a teacher named Georges Cuisenaire invented a system of colored rods that he had been using with students for 30+ years with great success. After observing that his students could easily understand the idea of whole notes, half notes, quarter and eight notes in music but had trouble with fractional relationships in math, Cuisenaire arrived at the idea of developing a mathematical keyboard. He created a system of ten rods, varying from 1 cm to 10 cm, each a different color. Incorporating this system into math instruction, his students' skills improved greatly, as did their enjoyment and understanding of math. Having recently celebrated the 75th anniversary, this set of simple colored rods is just as contemporary today and continues to be featured in many of the hands-on program produced by ETA/Cuisenaire.

By the early 1960's, Cuisenaire Rods and many other math manipulatives had made their way into American classrooms. The Cuisenaire Company of America (later acquired by ETA/ Cuisenaire) administered workshops to over 50,000 teachers between 1968-1978. Teachers clearly understood the benefits of a hands-on approach. However, the national perception of hands-on math really changed in 1983 when the Texas mathematics textbook adoption included the use of manipulatives. Over 90% of basal textbooks that year included manipulatives or illustrations of their use. Now many states, such as North Carolina, and Tennessee mandate a hands-on approach to math, requiring or strongly suggesting that manipulatives be incorporated into math instruction. In the 2000 revision of the NCTM Standards, Principles and Standards for School Mathematics, extensive use of hands-on materials is recommended and what's more, pictorial representations of manipulatives show up on a large number of state assessments, including California, Florida, Illinois, New York, Texas, and more.

Hand-in-Hand: Student Success and Teacher Quality

While the presence of hands-on materials in the classroom is commonplace, and research has generally shown that using math manipulatives is beneficial, still less than one out of four math teachers reports using hands-on learning activities with their students. However, teachers who do adopt a hands-on approach have students who outperform their peers by more than 70% of a grade level in math. Consistency matters, as the same study shows that when students engage in hands-on learning on a weekly basis rather than a monthly basis they are 72% of a grade level ahead of their peers in math. So, the most effective classrooms include a high-quality teacher that engages in professional development, emphasizes higher-order thinking skills and integrates hands-on learning activities (Wenglinsky, 2000).

Table 1

Impact of Teacher Inputs, Professional Development, Classroom Practices on Mathematics Achievement: Grade Levels

Aspect of Teacher Quality	Grade Level
Professional development in working with different student populations	107%
Hands-on learning	72%
Professional development in higher-order thinking skills	40%
Major/minor in math/math education	39%
Higher-order thinking skills	39%
Assessment without testing	-46%

Evidence abounds regarding the links among teacher quality, hands-on classroom practices and student success in math. There is also a great deal of recent research on such topics as which groups of learners benefit most, how often to employ the use of hands-on materials, what specific mathematical subjects are best taught with manipulatives, exactly what type of meaningful ways their use impacts students, and more.

Findings include:

- A hands-on approach to math instruction is especially effective for teaching students with learning disabilities, low achievers, and English language learners (Marsh and Cooke, 1996; Ruzic and O'Connell, 2001)
- A major goal of math interventions should be to use concrete materials to teach students to develop visual representations and how to transition these representations into standard symbolic representations (Institute of Education Sciences 2009 report on Response to Intervention)
- The use of manipulatives increases test scores and reduces errors on problem-solving tests (Carroll and Porter, 1997; Clements, 1997; Krach, 1998)
- Students using appropriate manipulatives to learn fractions outperform students who rely only on textbooks when tested on these concepts (Jordan, Miller, and Mercer, 1998; Sebesta and Martin, 2004)
- Students who used manipulatives in mathematics classes demonstrate higher algebraic abilities than those who did not use hands-on tools (Chappell and Strutchens, 2001)

- A study of 1,600 fourth- and fifth-graders showed that students using a hands-on math curriculum had statistically higher mean scores on posttests and retention tests than those students whose curriculum did not include use of manipulatives (Cramer et al., 2002)

Fulfilling the Need

As has become increasingly clear, supplying manipulatives alone isn't enough. One company is leading the way into a new era of hands-on math education. With nearly half a century of experience in the school market and a name that has become synonymous with "hands-on," ETA/Cuisenaire is uniquely suited to help educators put research about effective manipulative use into action. The company has developed dozens of research-based programs for grades K-12 that combine hands-on math materials with the lessons and instructional support needed to ensure student success. Many programs also feature professional development and training opportunities to ensure teacher quality. The company is committed to offering educators the resources they need to seamlessly integrate a total hands-on approach to math instruction.

For over thirty years, teachers have seen improved student achievement using the VersaTiles system. A self-correcting practice system that includes standards-based lessons for students in elementary and middle grades, VersaTiles features a unique answer case with tiles that students use in conjunction with an activity book. By creating the correct pattern as they answer the questions on a corresponding activity page the hands-on system promotes independent work, critical thinking, and confidence in students. Teachers have implemented the system successfully for daily practice, remediation, learning centers, enrichment, afterschool, summer school, and more. Recently, a VersaTiles math lab was used as part of a planned instructional intervention of Grade 8 Pre-algebra students. An increase in student achievement was noted and students reported enjoying using the hands-on activity. Teachers reported that VersaTiles was among the most effective strategies employed in the study because "the hands-on activity was visual and granted students the opportunity to enjoy learning..." (Daniely, 2007). This award-winning program continues to expand having recently answered the trend towards hands-on activities in the middle and upper grades by developing labs for problem solving and critical thinking and Algebra.

Another successful offering from ETA/Cuisenaire that puts research into action is the "Works" line, featuring programs for measurement, algebraic thinking, fractions, and geometry. By examining national test scores, the company saw that these key conceptual areas give students the most difficulty, but are also areas that lend themselves to improvement through hands-on instruction. Each Works program was designed to provide the hands-on experiences that would build students' conceptual understanding. By combining classroom tested lessons, a wide variety of hands-on tools, and extensive teacher support including assessments, the Works programs have lead to improved test scores. In one example, the Broward County, Florida school district implemented the MeasureWorks program after years of declining measurement scores. The MesaureWorks program was used with ESC students and is credited with a substantial increase in test scores: In less than one year, 62% of the students using the curriculum, had an increase of 10% or more on the state assessment test.

With the recent findings that less than one in four teachers use hands-on materials to teach math, ETA/Cuisenaire set out to develop a resource that would enable every teacher to be comfortable and successful using this approach. Having been described as the essential desktop reference, Hands-On Standards, Deluxe Edition has made a big impact on educators across the country. This series of ready-to-use, photo-illustrated books, available for PreK-Algebra 1, features standards-based lessons that move from the concrete to the abstract providing detailed support such as conceptual objectives, discussion prompts, assessment questions, and a "Look Out!" section that alerts teachers to common student misunderstandings. Each book in the series utilizes a wide variety of common classroom manipulatives and a helpful glossary familiarizes teachers with each one.

While some teachers may need the extensive support found in Hands-On Standards, Deluxe Edition, to integrate a hands-on approach, there are also educators who utilize hands-on lessons so often that they are continually looking for more resources. Supported by the theory that long-term use of manipulatives provide more benefits than short term use(Sowell, 1989), The Super Source offers a nearly endless library of hands-on activities that integrate easily into any curriculum. A series of resource books for Grades K-8, The Super Source is available organized by manipulative and grade span for K-6 and by strand in 7-8. The lessons in these books, 18 per book and over 450 across the series, offer in-depth discussions of mathematical content, and a comprehensive Scope & Sequence for aligning to any curricula.

Research has shown that a hands-on approach is particularly beneficial with groups of students such as English language learners and low achievers. ETA/Cuisenaire builds programs to fit these specific needs as well. With CenterStage Math, the company offers ready-to-use math centers that require little more prep time than unfolding the carrel and setting out manipulatives and activity cards. The hands-on activities in the centers provide enrichment for students who catch onto concepts quickly, and offer opportunities for reinforcing concepts with students who need additional support. Activity cards were carefully developed to support the math curriculum, covering topics in grades 1-5 such as place value, time & money, graphing, and more. Features like picture icons on student activity cards provide ELL/ESL support and the easy-to-follow teacher support allows even aids or afterschool facilitators to implement the program effectively.

In addition to CenterStage Math, Summer Stars Math is a new program that can be used to scaffold learning for struggling students. The use of manipulative-based activities has been cited as "significant and effective" when used in math interventions, and in fact using manipulatives in intervention is recommended not only in the early grades, but also the middle grades (Institute of Education Sciences 2009 report on Response to Intervention). Recognizing that summer school is a time when intervention services are typically provided, Summer Stars Math for Grades 3-6 is a highly customizable program that focuses on moving students to mastery. The program is easy for teachers to implement, featuring a unique online tool for scheduling and progress tracking/reporting. And since summer school classes are often comprised of a diverse group of students with varying abilities and learning styles, the program offers a wealth of hands-on lessons with which instructors can differentiate instruction and make math concepts more accessible.

Afterschool is another time when hands-on math may be used to provide intervention services as well as enrichment or extended learning. More and more students across the country are attending some form of afterschool program, and these programs are challenged with providing purposeful learning activities while keeping students who have already spent the day in school engaged. Learning Place for Afterschool Math for Grades 2-5 "disguises learning" of math skills to make instruction fun and effective. The program emphasizes hands-on activities based in part on the fact that the use of manipulatives has been proven by researchers to make learning fun (Moch, 2001; Smith, et.al, 1999). The program features hands-on games, small-group and individual activities, assessments, ESL/ELL supports, and more – all of which are easy for any leader or facilitator to implement.

Guided by the strong belief that incorporating a hands-on approach to math provides the best path to student success, and with the support of both scientifically based research and practical classroom successes, ETA/Cuisenaire will continue to develop new strategies and programs. Having moved beyond the goal of manipulatives in every classroom, the objective now is to provide educators with the resources needed to integrate a total hands-on approach to math instruction. Imagine a classroom rich with hands-on learning opportunities that move students from concrete experiences to abstract understanding. In the end this is the type of math environment that produces not only successful students, but also independent learners and thinkers.

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Manipulatives Use and Understanding in Mathematics

"I hear and I forget.
I see and I remember.
I do and I understand."

- Confucius (551–479 BC)

Overview

The use of manipulatives in teaching mathematics has become as almost commonplace as the use of textbooks. And with good reason, as both Sowell (1989) and Ruzic and O'Connell (2001) found that the long-term use of manipulatives has a positive effect on student achievement by allowing students to use concrete objects to observe, model, and internalize abstract concepts. Manipulatives not only allow students to construct their own cognitive models for abstract mathematical ideas and processes, it also provides a common language with which to communicate these models to the teacher and other students.

In addition to the ability of manipulatives to aid directly in the cognitive process, manipulatives have the additional advantage of engaging students and increasing both interest in and enjoyment of mathematics. Students who are presented with the opportunity to use manipulatives report that they are more interested in mathematics. And, long-term interest in mathematics translates to increased mathematical ability. (Sutton and Krueger, 2002)

History

Manipulatives are concrete objects that can be viewed and physically handled by students in order to demonstrate or model abstract mathematical concepts. They include a host of colorful shapes and objects including tangrams, cubes, and base-ten blocks.

The use of manipulative materials to teach mathematics has a long history. In the 19th century, influential Swiss educator Johann Pestalozzi (1746–1827) advocated the use of various manipulatives, such as blocks, to help children acquire abstract concepts, such as number sense, through concrete means (Saettler, 1990). In the early part of the 20th century, Montessori (1870–1952) founded schools and acquired a host of followers that believed in and stressed the importance of concrete, authentic learning experiences. It was her belief that children actualized their innate desire to learn through self-directed exploration of developmentally appropriate manipulatives (Ward, 1971).

In the 1960s and 1970s, the appearance of manipulatives in the elementary classroom increased rapidly following the publication of Zoltan Dienes' theoretical justification for their use. Since Dienes' work, a number of studies investigating the effectiveness of manipulatives have been conducted. The results have been somewhat mixed. However, there is general agreement among educators today that an effective mathematics curriculum in the elementary grades must include liberal use of manipulative materials. Such critical understandings as number sense, place value, operations, fractions, decimals, geometry, and algebra all can be effectively taught through the use of manipulatives. (See Table 1.)

Support from the Classroom

Elementary school teachers have generally accepted the importance of manipulatives in teaching and learning math. In a recent nationwide survey of 1,000 members of the National Education Association (NEA, 2002 Instructional Materials Survey), for example, nearly half (49%) of the elementary school teachers surveyed said that they use manipulatives every day as part of their instructional methods. When asked to rate the effectiveness of various instructional materials, almost seven in ten teachers in the national sample (67%) rated manipulatives as “highly effective” tools for instruction. Among elementary school teachers, 85% rated manipulatives as highly effective. Respondents rated other instructional materials (i.e., textbooks, handouts, computer software, etc.) relatively the same (between 30–40% rate each highly effective). (See Table 2.)

Support from Learning Theory

Learning theory indicates that mathematical understanding in young children is closely associated with sensory perception and concrete experience. Children begin to understand symbols and abstract concepts only after experiencing the ideas on a concrete level (Piaget, 1952). Manipulatives are effective tools in mathematics education by helping children move from a concrete to an abstract level of understanding. Students who see, touch, sort, take apart, and manipulate physical objects begin to develop clearer mental images and can represent abstract ideas more completely than those whose concrete experiences are limited (Heddens, 1986). Children whose mathematical learning is firmly grounded in manipulative experiences will be more likely to bridge the gap between the world in which they live and the abstract world of mathematics (Dienes, 1960).

Support from Research

Much research into the use of manipulative materials and their benefits to children has been conducted over the years. Although some researchers have questioned the value of manipulatives in teaching mathematics (e.g., Friedman, 1978; Raphael and Wahlstrom, 1988), research has demonstrated that manipulatives generally have a positive effect on student achievement and mathematical learning compared to more traditional instructional methods that place a heavy emphasis on the use of worksheets and computational fluency (Bisio, 1971; Fennema, 1972; Suydam and Higgins, 1977; Driscoll, 1981; Parham, 1983; Sowell, 1989; Cramer et al., 2002).

- Bisio (1971) analyzed the effectiveness of three different methods for teaching the addition and subtraction of fractions with like denominators. In the first method, teachers and students did not use manipulative materials; in the second method, the teacher used manipulatives only to demonstrate concepts for students; in the third approach, both teachers and students used manipulatives. Although Bisio found that the passive use of manipulatives by the teacher (method 2) was just as effective as the active use by students (method 3), both approaches were much more effective than the instructional approach in which manipulatives were not used at all.

- Fennema (1972) summarized research on the use of Cuisenaire rods to teach arithmetic compared to more traditional approaches. She found that research generally supported the use of the manipulative for first-graders, but that the value of the rods for second- and third-graders was less conclusive. Fennema concluded, "There is some indication that children learn better when the learning environment includes a predominance of experiences with models suited to the children's level of cognitive development." Her recommendations were that teachers use manipulatives to teach math in the early grades and then gradually decrease their use as students are able to grasp concepts more symbolically.

- Suydam and Higgins (1977) performed a meta-analysis of 40 research studies into the use and effectiveness of manipulatives on student achievement in math. 60% of the studies indicated that manipulatives had a positive effect on student learning; 30% showed no effect on achievement; and 10% showed significant differences favoring the use of more traditional (non-manipulative) instructional approaches. In similar work, Sowell (1989) performed a meta-analysis of 60 additional research studies into the effectiveness of various types of manipulatives with kindergarten through post-secondary students. On the basis of this research, she concluded that achievement in mathematics could be increased through the long-term use of manipulatives.

- Parham (1983) analyzed 64 research studies into the use of math manipulatives at the elementary level. Generally, she found that there were significant positive differences in achievement of students who had used manipulatives as part of their math instruction compared to those who had not.

- In a recent study of 1,600 fourth- and fifth graders, Cramer et al. (2002), compared the achievement of students using a commercial curriculum for learning fractions with the achievement of students exposed to a specialized curriculum that placed great emphasis on the use of manipulatives. Students using the manipulatives-based curriculum had statistically higher mean scores on posttests and retention tests.

Manipulatives have also been shown to be particularly effective instruments in promoting mathematics understanding in students with learning disabilities (Thornton and Wilmot, 1986).

- Miller and Mercer (1993) investigated the effects of three different phases of instruction—concrete, semiconcrete, and abstract—on the computational skills of LD students. In the concrete phase, concepts were introduced using concrete manipulatives. The semiconcrete phase involved practice with pictorial representations of the objects. The abstract phase presented students with abstract symbols (e.g., numbers) only. Students instructed in this manner demonstrated marked improvements in the acquisition and retention of concepts.

- Marsh and Cooke (1996) analyzed the effects of using manipulatives (Cuisenaire rods) in teaching third-grade LD students to identify the correct operations to use when solving math word problems. After using the manipulatives, students showed statistically significant improvements in their ability to identify and use the correct operations to solve the problems.

Support from National and State Curriculum Standards

In the 1989 publication *Curriculum and Evaluation Standards for School Mathematics*, the National Council of Teachers of Mathematics (NCTM) strongly emphasized the importance of manipulatives in math education, particularly at the elementary level. For example, the K–4 standard for number sense and numeration states, "Children come to understand number meanings gradually. To encourage these understandings, teachers can offer classroom experiences in which students first manipulate physical objects and then use their own language to explain their thinking. This active involvement in, and expression of, physical manipulations encourages children to reflect on their actions and to construct their own number meanings. In all situations, work with number symbols should be meaningfully linked to concrete materials."

The recent revision of the NCTM Standards, *Principles and Standards for School Mathematics,* published in 2000, also recommends extensive use of manipulative materials, particularly in the early grades: "Representing numbers with various physical materials should be a major part of mathematics instruction in the elementary school grades."

Most states also explicitly mandate the use of manipulatives through their curriculum frameworks, and pictorial representations of manipulatives often show up on state assessments. (see, for example, the state frameworks of California, Florida, Illinois, New York, New Jersey, and Texas at http://enc.org/professional/standards/state/)

Summary

The importance of providing students with direct experiences with concrete materials is supported by evidence from the classroom and an understanding of how learning takes place. While children can remember information taught through books and lectures, studies show that deep understanding and the ability to transfer and apply knowledge to new situations requires learning that is founded in direct, concrete experience. An important justification for hands-on learning, then, is that it allows students to build functional understanding and an ability to inquire themselves, in other words, to become independent learners and thinkers.

It is also important to note that children cannot learn math simply by manipulating physical objects. When using manipulatives, teachers should closely monitor students to help them discover and focus on the mathematical concepts involved and help them build bridges from concrete work to corresponding work with symbols.

There is no single best way to teach math. However, research shows that using manipulatives in conjunction with other methods can deepen students' understanding of abstract concepts. Appropriate use of manipulatives should be one component of a comprehensive mathematics curriculum."

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Preparing Eighth-Grade Students for Algebra in the Ninth Grade

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Approval Page

This applied dissertation was submitted by Julia Mitcham Daniely under the direction of the persons listed below. It was submitted to the Fischler School of Education and Human Services and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova Southeastern University.

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Abstract

Preparing Eighth-Grade Students for Algebra in the Ninth Grade. Daniely, Julia M., 2007: Applied Dissertation, Nova Southeastern University, Fischler School of Education and Human Services. Algebra/Mathematics Achievement/Middle School Students/ Mathematics Instruction/Prealgebra

This applied dissertation study was designed to increase the mathematics knowledge and improve the readiness of 309 Grade 8 prealgebra students for algebra in Grade 9. The goal was to decrease the number of Grade 9 students failing Algebra I at the local, public high school that the majority of participating students attend. The percentage of Grade 8 students meeting or exceeding mathematics standards on the 2005 Criterion Referenced Competency Test (CRCT) was lower than the state average. In addition, the local, public high school's End-of-Course Test results in Algebra I showed that only 52% of 556 Grade 9 students met or exceeded state standards in 2005.

The researcher designed and developed a staff development program in an effort to improve mathematics instruction of participating teachers. Research addressed effective instructional strategies, described a school improvement effort that improved student performance, and noted algebra readiness indicators developed by the Southern Regional Education Board. Research-based strategies shown to be successful in previous studies played a major role in the design of the methodology. The following instructional strategies were incorporated: cooperative learning, simulation and games, peer tutoring, direct instruction, critical thinking activities, and the use of manipulatives.

As a result, 72% of participating students met or exceeded state standards in mathematics on the 2006 CRCT, compared to only 52% meeting or exceeding standards in 2005. Students' scores improved from pretest to posttest on the Iowa Algebra Aptitude Test; 18% of Grade 8 students obtained a 46 (out of 63) on the pretest, compared to 50% meeting this benchmark on the posttest.

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Chapter 1: Introduction and Background

Introduction

Middle grades signify a key turning point in the lives of students (National Council of Teachers of Mathematics [NCTM], 2004). The NCTM noted that during middle grades, students set ideals regarding themselves as learners of mathematics. The NCTM mentioned that students establish conclusions concerning their level of proficiency in the subject, their attitudes, their awareness, and their inspiration. These conclusions will contribute to how students advance in the study of mathematics in subsequent years, which inadvertently will influence their future career and personal advancement (NCTM).

Middle school is a critical period in the development of algebraic thinking (Stiff, 2003). A vital component to the success of students in Algebra I at the ninth-grade level is the consideration of how best to prepare mathematics students throughout middle school (Steen, 1999). Carpenter and Bottoms (2003) defined a student with algebra readiness as one who has the cognitive and psychological ability to understand and demonstrate mastery of essential concepts, skills, and abilities that lead to success in an algebra course. Algebra prepares adolescents for higher level mathematics courses (Carpenter & Bottoms).

The No Child Left Behind Act of 2001 (NCLB, 2002) is legislation signed by President Bush in 2002 that reauthorized the Elementary and Secondary Education Act. This legislation raises the expectations for states, school districts, and schools with the purpose of all students meeting or exceeding state standards in reading and mathematics by 2014. Adequate Yearly Progress is the central ideal of NCLB. It is a mechanism designed to measure the year-to-year student achievement on statewide assessments (LD

Online, 2003). To make Adequate Yearly Progress, each school and district must meet three criteria: (a) have a 95% student participation rate on state assessments, (b) meet or exceed standards on the state assessment, and (c) meet the standard or show improvement on a designated second indicator (NCLB). For the 2003–2004 school year, the study site did not meet Adequate Yearly Progress in two areas: reading performance of students with disabilities, as measured by the state Criterion-Referenced Competency Test (CRCT), and attendance (over 15% of the student population missed more than 15 days in a school year). Based on data for the 2004–2005 school year, NCLB standards placed the school on the in-need-of-improvement list, based on students with disabilities not improving in academic performance (mathematics) and 18% of the student population missing more than 15 days during this school year.

In order for a student to graduate from high school in the district in which this applied research study was conducted, each student must pass an algebra course. NCLB emphasizes stronger accountability for schools and the utilization of research-based methods of instruction (LD Online, 2003). NCLB has mandated assessments as indicators of academic proficiency (U.S. Department of Education, 2005). In Georgia, the state where the research study took place, a statewide assessment, End-of-Course Test (EOCT), had been instituted as an indicator of achievement in algebra.

Setting

The middle school in which this applied research study was conducted is an inner-city magnet school. The focus of the magnet program is Core Knowledge, with a major emphasis on fine arts: orchestra and band, chorus, art, and dance. The district approved the study's site adoption of the Core Knowledge curriculum and granted the school its magnet status upon the principles of Core Knowledge. Both the magnet school and the

Core Knowledge curriculum initially were implemented at the study site during the 1996–1997 school year. The curriculum provides a planned sequence that seeks to close the gaps that many young Americans have in their basic knowledge of history, geography, science, mathematics, literature, and the arts, from which effective citizenry is attained (Core Knowledge Foundation, 1999). Students throughout the city were offered the choice to attend the study school.

At the time of this study, the study site had 735 students; 85% of the population was African American, 10% was White, 2% was multiracial, and 2% was Hispanic. Neighborhood and zoned students comprised 71% of the population, and 29% were magnet students. The socioeconomic status of the students attending this school reflected the diversity of the population: 78% received free or reduced-price meals. The study site is a targeted-assisted Title I school, meaning students not meeting standards and who were economically disadvantaged received additional services in mathematics and reading.

The school in which this applied dissertation study took place had 47 professional staff members, 39 of which were female. Sixty-three percent of the teachers at the school had a master’s or higher advanced degree. Thirty-two teachers had over 10 years of experience.

The community in which the study site is located had a population of 321,000. The median age was 34.9 years. Sixty percent of the city’s population was White and 39% was African American. American Indians, Alaskan Natives, Asians, and Native Hawaiians comprised less than 1% of the population. Eighty-four percent of the population 25 years and older had a high school diploma, and 20% had a bachelor’s degree or higher. Among 16-year-olds, 15% were dropouts, according to the local chamber of commerce's 2005 statistics. The total K–12 school enrollment in the community was 85,000, which included both public and private school populations. The median household income was $39,761. The poverty level was 16%, with 33% of households headed by a woman. Twenty-five percent of the population received public assistance sources.

The public school system in which this applied dissertation study was conducted serves prekindergarten through Grade 12 students from both the city and greater county. An elected board of education and an appointed superintendent of schools manage the system. The schools in the system are fully accredited by the Southern Association of Colleges and Schools. The annual system budget for the 2005–2006 school year was $144.4 million; the average expenditure per student was $5,852, according to the local chamber of commerce.

The researcher was a professional status mathematics teacher instructing on the eighth-grade level and responsible for three prealgebra classes and an algebra class. Some of the researcher's additional responsibilities included program director for the after-school program; 4-H Club sponsor; school-wide mathematics tutor, particularly for those with special needs; and a participating member of Closing the Achievement Gap (CTAG). CTAG is a system-wide initiative to improve performance by adapting an eight-step instructional process to the current curriculum (Davenport & Anderson, 2002). Davenport and Anderson described how this design improved schools in Texas. Davenport and Anderson personally trained the study site's CTAG team prior to this study.

The researcher was also the instructional leader for a four-teacher cluster at the school and for the mathematics department. The cluster within this applied research study also included resource teachers who served special-needs students. The operational definition of a cluster in the study school is a group of teachers serving a specific population of students in core subject areas. The clusters are arranged by the school's administrators according to students' music class (strings, band, and chorus) and exceptionalities (learning disabled, emotional behavior disorder, severely emotional behavior disorder, speech impaired, and hearing impaired). The study school had three Grade 8 clusters, three Grade 7 clusters, and one Grade 6 cluster.

The principal for the study site requested that the researcher assume a leadership role in developing and implementing a plan to improve mathematics achievement of eighth-grade prealgebra students. After completing this study, the researcher became the instructional lead teacher at the study site. The principal was seeking consistency in prealgebra instruction across the grade level. This decision was based on the poor performance of Grade 8 students on the 2005 CRCT in mathematics. In order to follow state law and state board of education rules, the county gives the CRCT to students in Grades 1–8. A state rule requires students to score at grade level in reading and mathematics on the Grade 8 CRCT in order to be promoted to the next grade level beginning in 2006. Students must obtain a score of 800 in reading and 300 in mathematics (at grade level) or above.

Background and Significance of the Problem

At least half of ninth-grade students were failing algebra at a local, public high school (Georgia Department of Education, 2005). Based on research from California (Ezarik, 2002), the researcher proposed that improving students' mastery of state standards through eighth-grade prealgebra instruction would improve students' readiness for algebra at the ninth-grade level. Students are held responsible for objectives requiring higher order thinking within specific domains of knowledge (Flick & Lederman, 2002). The California Department of Education expressed that districts needed more time to improve the quality of teaching before students could be held accountable to the standards (Ezarik). As a result, Ezarik noted that kindergarten through Grade 7 (K–7) standards have to be implemented properly to transition students to algebra. The research cited supported the need for emphasis on meeting the state standards at the study site to improve students' readiness for algebra.

The Southern Regional Education Board (SREB) in their Middle Schools That Work initiative developed 12 content-specific readiness indicators purported to be the essential content to better prepare middle school students for an algebra course (Carpenter & Bottoms, 2003). Carpenter and Bottoms, SREB consultants, suggested the following 12 things students should know to demonstrate readiness for Algebra I: (a) Read, write, compare, and order real numbers; (b) compute with or without technology; (c) use number sense; (d) apply ratios, rates, and percents; (e) conceptualize geometric figures; (f) determine measurement; (g) use and apply the Pythagorean theorem; (h) interpret data; (i) find the probability of events; (j) solve algebraic equations; (k) recognize patterns; and (l) understand functions algebraically and graphically. Carpenter and Bottoms's list is similar to the state's objectives for eighth-grade mathematics. The state-mandated Grade 8 mathematics objectives are divided into six domains with standards that support the skills necessary for success in algebra. The researcher aligned these readiness indicators with state standards as a basis for the development of an instructional sequence (see Appendix A).

Prior to the 2004–2005 school year, a ninth-grade student's final grade was based on 20% for the final exam (district test) and 80% coursework (90% teachers' tests, 10%

homework and classwork). The EOCT, a state assessment for algebra, was given at the end of the 2003–2004 school year; 53% of ninth-grade students failed. The scores on the state exam were not used in calculating a student's final grade for 2003–2004. However, beginning in 2004–2005, the state required that the EOCT score represent 15% of a student's average.

In an attempt to address the achievement problems of students in all academic areas, the superintendent of schools in 2000–2001 organized a community-based forum. High school mathematics teachers who attended the forum indicated to the middle school teachers that students lacked the preparatory skills and mental readiness for algebra. Their comments were supported by the SREB research and the California Department of Education study (Carpenter & Bottoms, 2003; Ezarik, 2002).

Problem Statement

The eighth-grade prealgebra students at the study site performed significantly lower than eighth-grade students in the state on the CRCT (see Tables 1 and 2). The CRCT results indicated that these prealgebra students were not meeting the standards necessary for them to achieve in order to be successful in algebra. These students were slated to be placed in algebra in ninth grade. According to school district records, 90% of these students were zoned to attend the high school where at least half of ninth-grade students failed algebra.

Data included in Table 1 indicate improvement from 2000–2001 to 2003–2004 in overall mathematics achievement, as evidenced by CRCT results, for eighth-grade students at the study site and in the state. However, eighth-grade prealgebra students at the study site were still performing significantly lower than eighth-grade students in the state. This applied dissertation study was developed and implemented to assist in improving this problem so that students would be ready for algebra in Grade 9.

Table 1

Percentage of Grade 8 Prealgebra Students Who Met State Standards on the Criterion-Referenced Competency Test, 1999–2005

	% Students meeting state standards	
School year	School	State
1999–2000	55	—
2000–2001	47	—
2001–2002	54	65
2002–2003	56	67
2003–2004	66	73
2004–2005	52	69

There was a significant decline at the study site as well as for the state in the percentage of students meeting or exceeding state standards from 2003–2004 to 2004–2005. These students were promoted to the ninth grade ill prepared for the course.

Data included in Table 2 show the percentage of Grade 8 prealgebra students in the study school and Grade 8 students in the state who met or exceeded state standards for each of the domains. The average for the school was significantly below the state average. Grade 8 mathematics achievement in Number Sense and Numeration, Geometry and Measurement, Patterns and Relationships or Algebra, Statistics and Probability, Computation and Estimation, and Problem Solving (see Table 2) was lower than the state average in each of these areas.

Purpose Statement

The purpose of this applied dissertation study was to research, develop, implement, monitor, and evaluate an intervention designed to better prepare eighth-grade students enrolled in prealgebra for algebra in the ninth grade. There was a major focus placed on Grade 8 mathematics state standards based on SREB research (Carpenter & Bottoms, 2003) and the California Department of Education study (Ezarik, 2002). The researcher aligned the readiness-for-algebra indicators with the state standards.

Table 2

Percentage of Grade 8 Prealgebra Students Meeting the State's Criterion-Referenced Competency Test Standards by Domain, 2004–2005

	% Students meeting standards	
Domain	School	State
Number Sense and Numeration	56	70
Geometry and Measurement	47	65
Patterns and Relationships/Algebra	57	67
Statistics and Probability	54	66
Computation and Estimation	55	68
Problem Solving	52	63
Average	52	69

The district utilized the Iowa Algebra Aptitude Test (IAAT; Schohen, 1993) to assess the readiness of students for an algebra course. Therefore, in this applied research study, the IAAT was utilized to measure participating eighth-grade prealgebra students' readiness for algebra in the ninth grade. These results also were used to measure the intervention's effectiveness.

Research Questions

Through this applied dissertation study the researcher endeavored to answer the following two research questions:

1. Would an instructional intervention result in improved mathematics achievement of participating eighth-grade prealgebra students, as evidenced by an increased percentage meeting or exceeding the state standards, as measured by the CRCT, for each of the state domains (Number Sense and Numeration, Geometry and Measurement, Patterns and Relationships or Algebra, Statistics and Probability, Computation and Estimation, and Problem Solving), compared to the percentage who met or exceeded state standards the previous school year?

2. Would an instructional intervention result in improved readiness of participating eighth-grade prealgebra students for algebra, as indicated by a higher postintervention percentage of participating prealgebra students obtaining a score of 46 or higher on the IAAT than the preintervention percentage?

Definitions of Terms

Core Knowledge is a term and resulting curriculum introduced by Hirsh (as cited in Core Knowledge Foundation, 1999) to describe what he viewed as a planned sequence that seeks to close the gaps that many young Americans have in their basic knowledge of history, geography, science, math, literature, and the arts. This sequence was adopted at the study school in 1996–1997. During the 1996–1997 school year, mathematics state assessment scores improved by 12 points but have fluctuated 1997–2005. The sequence was not aligned with the state mathematics standards; however, it provided enrichment for students and the content presented was an introduction to concepts for future mathematics courses. The curriculum provides students with everything they need to know, present and future (Core Knowledge Foundation)

A *cluster* is a team of four teachers who specialize and instruct in one of four content areas—(a) mathematics, (b) science, (c) social studies, and (d) language arts—as well as resources teachers who work with special-needs students in inclusion and self-contained settings. The clusters in the study school were developed by the administration and registrar. The students were grouped by their fine arts selection and exceptionality.

The *End-of-Course Test (EOCT)* is the state assessment given to students at the conclusion of the Algebra I course. This assessment is an accountability tool used as a means to meet the goals of NCLB. The EOCT was designed to evaluate whether students have mastered state algebra standards.

The *Criterion-Referenced Competency Test (CRCT)* is a state assessment designed to measure how well students acquire the skills and knowledge described in state standards.

The *Iowa Algebra Achievement Test (IAAT)* is an instrument that measures algebra readiness and predicts the success rate of students in a future algebra course (Schohen, 1993).

State standards are specific objectives outlined by the state for Grade 8 mathematics students. Teachers are required by the state to incorporate these objectives in their instructional design. The mathematics state standards are grouped in six domains: (a) Number Sense and Numeration, (b) Geometry and Measurement, (c) Patterns and Relationships or Algebra, (d) Statistics and Probability, (e) Computation and Estimation, and (e) Problem Solving.

Summary

Middle school is a critical period in terms of developing algebraic thinking (Stiff, 2003). This study was designed to improve the readiness of participating middle school prealgebra students for algebra at the ninth-grade level. The researcher determined the mastery by these students in all domains as evidenced by their mastery of the state standards assessed on the CRCT. This mastery or lack thereof contributes to the deficiency in preparedness of students for a ninth-grade algebra course (Carpenter & Bottoms, 2003; Ezarik, 2002). A research-based intervention was utilized to assist in students' mastery of essential skills necessary to excel in algebra. An algebra readiness test (IAAT) was used to determine the preintervention level of the students and quantify their performance after the intervention was completed. Students also were assessed weekly to monitor their progress in mastering Grade 8 mathematics state standards.

Chapter 2: Review of Literature

Introduction

Middle school students are unique. Throughout these years, students have an array of intellectual, physical, psychological, and social development (Letrello, 2003). Letrello noted that most students consider middle school an opportunity to expand a sense of academic principles and individual assurance to learning goals. However, Honig (1987) stated that students who are not successful at the middle school level frequently drop out of school and never have the chance to attain their full potential.

Generally, students in middle school become disenchanted with mathematics, thus becoming less apt to take college preparatory mathematics courses like algebra (Sowder, 2003). Phillips and Smith (2000) were concerned with the best way to teach the essential skills needed to be successful in algebra and also to assess students. According to Mathews (2002), algebra becomes a key instructive hurdle for students. Students who do not take algebra are not expected to strive for a college education (Pascopella, 2000). The NCTM (2004) stated middle school students should be challenged and supported in mathematics classrooms in order for them to be intrigued by the subject.

This literature review was organized into topics that explored areas in research that addressed students' performance in mathematics at the middle school level and how it affects performance in an algebra course. It was considered additionally vital to discuss the probable causes of students' lack of achievement of mathematics concepts essential for success in algebra. The researcher examined literature on standards-based curricula and prioritized curricula to distinguish if these current trends can increase students' mastery of essential skills necessary to excel in mathematics. Furthermore, the review of literature identified the skills students need to excel in an algebra course and discussed research-based interventions that have been successful in increasing students' mathematics achievement.

Possible Causes of Student Failure in Mathematics

Developmental needs of middle school students contribute some degree to the lack of performance in academic courses (Letrello, 2003). Letrello noted that middle school students experience physical growth and change, whereas Wiles and Bondi (1993) described students during these years as being emotionally instable. Roeser, Eccles, and Sameroff (2000) used a survey in a study to establish psychological reasons why middle school students have academic problems during these critical years. They concluded that academic performance depended on whether the students felt that challenges could be met in the classroom. Banks (2003) additionally stressed the need for teachers to include students in the decision-making process of the instructional design in the classroom.

Rosser et al. (2002) recommended not only that students be taught by highly qualified teachers, but also that these teachers instruct to students' interests and prepare developmentally appropriate lessons relevant to the lives and experiences of these students in order to stimulate learning. Chung, Elias, and Schneider's (1998) research supported the research findings of Roeser et al. Using varied surveys and measures, they concluded that both boys and girls in a 99-student sample who were entering a New Jersey middle school showed an increase in psychological distress after transition into middle school. School officials need to understand better the diverse ways that middle school students adjust to the transition into middle school in order to address holistically the needs of students and provide the necessary services to ensure success in all subject areas (Banks, 2003).

What is evident is that mathematics continues to be a high-profile subject that has the attention of politicians, educators, businesses, and families (Allen, 2003). Americans have become disenchanted with mathematics at the middle school level, because teachers lack the training to teach mathematics topics vital for success in algebra (Association for Supervision and Curriculum Development, 2003). Only 41% of U.S. eighth graders are taught by teachers who have mathematics degrees (Hoff, 2000). At the study site, 1 teacher has a secondary mathematics certification. The other 2 teachers are middle-grades certified in mathematics and are allowed to teach algebra because of course requirements mandated by the district.

Bottge (1999) investigated the effect of contextual mathematics instruction on the problem-solving performance of middle school students in prealgebra. Contextual teaching and learning in mathematics represent a theory that encompasses linking the content that students are learning with relevant real-world contexts. Relating content with context is a vital part of bringing significance to the learning process (Berns & Erickson, 2000). Berns and Erickson used a quasi-experimental design for their study. The purpose of the study was to compare the impact of word-problem instruction and contextual-problem instruction on computation skills and problem-solving performance. Results showed that the use of contextual problems enhanced the problem-solving skills of students in average mathematics classes. Contextual problem-solving instruction provides an opportunity for practice of situating problems in a significant context to improve the mathematics problem-solving skills of prealgebra students (Bottge).

High-stakes testing is currently debated at all levels of the educational organization (Amrein & Berliner, 2002). NCLB (2002) mandates accountability within these levels. Amrein and Berliner noted that high-stakes testing benefits teachers and students because they know what is important to learn and teach. Teachers need to be held accountable in an effort to motivate them to teach better, which will in turn motivate students to work harder and learn more. There are punishments attached to high-stakes testing. Forty-five states hold schools accountable for their test scores by publishing school and district report cards (Amrein & Berliner).

In California, there was a concern that districts needed more time to improve the quality of teaching before students could be held accountable to the higher standards (Ezarik, 2002). The California Department of Education mathematics specialist (as cited in Ezarik) noted that K–7 standards have to be implemented properly to transition students to algebra.

At the study site, there was an increasing percentage of prealgebra students not meeting state standards (see Tables 1 and 2). Increasing the percentage of participating students meeting or exceeding state standards was one of the objectives of this applied research.

Mathematics teachers should construct learning environments that mirror this type of curriculum and that lead to the achievement of all students (Flick & Lederman, 2002). Classrooms using an aligned standards-based curriculum while encompassing research-based strategies transform a school into a successful one (Reeves, 1997). Marzano (2003) expressed that standards hold the highest expectation for considerably improving student achievement; thus, the standards movement must be the centralization in instructive focus in public education. Marzano (2003) further noted that teachers must take part in staff development opportunities, which are critical in the standards-based movement. A survey of 1,000 teachers indicated the following three features of staff development that had a strong impact on changing teacher behavior: (a) a focus on content, (b) an opportunity for active learning, and (c) a consistency of staff development activities (Marzano, 2003).

Several districts have summer programs for middle school students and employ mathematics coaches to help teachers utilize strategies such as lecturing less and questioning students to communicate mathematics reasoning (Ezarik, 2002). This method was substantiated by M. Cohen (2001), who brought attention to the failure of students whose teachers rely on a lecture format and emphasize delivery of content, without looking for evidence of learning or mastery of knowledge and skills. Consequently, such teacher behavior results in student alienation, boredom, stressed relationships involving adults and students, and social concerns that weaken efforts to increase academic achievement (Byrk & Schneider, 2002).

According to Black (2004), many students leave middle school ill prepared for algebra at the ninth-grade level. State officials who hoped to raise standards comparable to those in Japan indicated that students remain low in mathematics competencies. Educators across the country stated that the effort to improve and accelerate middle school mathematics instruction was suffering because school boards, principals, and teachers begin teaching students utilizing the versions of algebra that are not thorough, thus contributing to students' ill preparedness for higher level mathematics courses (Mathews, 2002).

Skills That Students Need to Be Successful in Algebra

According to the U.S. Department of Education (1997), proficiency in mathematics, including qualitative and problem-solving skills, is a requirement for partaking in the existing work force. However, 40% of U.S. eighth graders did not attain the basic mathematics level, and 76% did not reach the proficient level, as measured by National Assessment of Educational Progress (Reese, Miller, Mazzeo, & Dossey, 1997). The U.S. Department of Education (1997) made it a main concern for students to take the basics of algebra by the conclusion of eighth grade, because algebra is the key to potential achievement in highly developed mathematics and the focal point for preparing students for college. National Assessment of Educational Progress findings for students implied that a vast number of them do not have the computational skills they need before entering an algebra course (Bottoms, 2000).

Mathematics is an intricate component for success in the workplace (U.S. Department of Education, 1997). Acquiring and succeeding in the jobs of today's economy require a variety of mathematical skills and concepts (Bottoms, 2000). Bottoms cited a statement by the National Association of Manufacturers that "poor reading, writing, math and communication skills were cause for concern" (p. 1) and a deterrent to preparing students for algebra. Educators must reflect on and develop strategies to assist students be successful (Fernandez & Anhalt, 2001). For example, investigations utilizing concrete objects, information graphs, and symbols are crucial to students' mathematical foundation in transitioning to algebra; it is vital to develop a profound understanding of decimals, fractions, ratio and proportion, measurement, integers, functional relationships, and variables (Fernandez & Anhalt).

Carpenter and Bottoms (2003) suggested 12 things students should know to demonstrate readiness for Algebra I: (a) Read, write, compare, and order real numbers; (b) compute with or without technology; (c) use number sense; (d) apply ratios, rates, and percents; (e) conceptualize geometric figures; (f) determine measurement; (g) use and apply the Pythagorean theorem; (h) interpret data; (i) find the probability of events; (j) solve algebraic equations; (k) recognize patterns; and (l) understand functions algebraically and graphically. Bottoms (2000) developed the following six key procedures to improve students' mathematical experiences: (a) hire teachers with mathematical knowledge, (b) implement a curriculum in the middle grades that prepares students for success in Algebra I, (c) actively engage students in learning mathematics, (d) use real-world problems to teach mathematics, (e) create a climate of high expectations in math classes, and (f) provide students with extra help.

Bottoms (2000) described readiness indicators for an algebra course as problem solving, reading and communicating, estimating and verifying answers and solutions, logical reasoning, and using technology. These indicators are similar to the standards that were used as one of the basis for this applied research study. These indicators are important because most mathematics curricula and educators in Grades 7 and 8 duplicate skills taught in lower grades before engaging students with tasks designed to deepen their understanding of the noted essential readiness indicators (Bottoms).

Bottoms (2000), senior vice president of the SREB, spearheaded the report for middle school mathematics educators to aid them in the preparation of students for Algebra I. The report was designed to help middle school teachers set goals and priorities for mathematics that will get all students ready for an algebra course (Bottoms). Bottoms, a panel of teachers, and experts from the Educational Testing Service noted that this report provided a pathway for a thorough mathematics program in the middle grades and reinforced previously taught skills for mathematics courses at the high school level.

Excellent mathematics instruction, based on the premise of using important, concrete standards, can assist in the preparation of all students to excel at the basic proficiency level and can result in a progressing percentage of students performing at the proficient level (Bottoms, 2000). Burns (1993) suggested the following 12 things that mathematics educators can do to be more effective in ensuring skill mastery of students: (a) setting sensible goals for students, (b) having students communicate mathematical thoughts in every case, (c) communicating mathematically with peers and working cooperatively, (d) incorporating writing in instructional design as a part of learning concepts, (e) embedding mathematics investigations in context, (f) using tangible objects to explain concepts, (g) utilizing strengths of students to engage them in mathematics, (h) using technology, (i) allowing students to drive the curriculum, (j) staying abreast of activities that meet the needs of individual students, (k) understanding the needs of students and allowing them to learn at their own pace, and (l) encouraging diverse thinking.

Preparing Middle School Students for Algebra

Algebra provides an opportunity for students to enroll in and advance in mathematics courses, thus being what educators call a gate-keeper (Carpenter & Bottoms, 2003). As noted earlier, Bottoms (2000) analyzed school improvement data from 100 middle schools and noted the following six strategies to improve students' mathematical performance: (a) Hire teachers with knowledge of mathematical content and strategies to teach mathematics, (b) implement a curriculum in the middle grades that prepares students for success in Algebra I and higher level mathematics courses, (c) engage students in learning mathematics, (d) use real-world problems to teach mathematics, (e) create a climate of high expectations in mathematics classes, and (f) provide students with extra help.

The NCTM noted the following four standards for students in Grades 6–12: (a) Understand patterns, relations, and functions; (b) represent and analyze mathematical situations and structures using algebraic symbols; (c) use mathematical models to represent and understand quantity relationships; and (d) analyze change in various contexts. The NCTM highly recommended that teachers be conscious of these basic standards and implement them in daily lessons to effectively prepare middle school students for algebra. Development of algebraic thinking by using research-based strategies is critical for mathematics teachers to incorporate in their instructional designs in an effort to teach students how to think and reason (Janzen, 2005).

Research-Based Strategies and Interventions

Various educational research studies have been done to identify interventions or practices that can be altered into interventions for improving students' intellectual attainment (Gall, Gall, & Borg, 2003). Marzano (2003) suggested that each teacher needs to decide on an instructional design at the classroom level based on the nature and needs of the students. According to Marzano (2003), the following three main principles from cognitive psychology outline an effectual classroom instructional design: (a) Knowledge is improved when a teacher identifies the necessary skills that are the focal point of a lesson, (b) knowledge requires participation in activities that are well designed and appropriately sequenced for transference of previously learned concepts, and (c) knowledge requires varied exposure to enriching opportunities. These principles are based on the following six achievement steps: (a) including fundamentals of content, (b) being certain that students have various exposures to content, (c) identifying procedures to be mastered, (d) arranging concepts to be mastered, (e) using activities that use the process of equalization, and (f) engaging students in VersaTiles activities that require them to experience learning in unique ways (Marzano, 2003).

Former Secretary of Education Bennett (as cited by Marzano, 2003) stated it was necessary to identify instructional interventions that enhance student achievement in mathematics. He and other researchers noted the following 11 practices used by efficient teachers: (a) the use of experiments, (b) teacher estimation strategies, (c) high teacher expectations, (d) positive reinforcement, (e) classroom time management, (f) direct instruction, (g) memorization, (h) use of manipulatives, (i) use of questioning, (j) homework, and (k) classroom assessment. These practices are highly recommended for teachers, but the development of an effective instructional design is vital (Marzano, 2003).

Practices such as class-wide peer tutoring have been used successfully as effective instructional interventions for students who tutor one another in the same classroom (Allsopp, 1997). Some benefits include providing students with many opportunities to respond to academic tasks and frequent and immediate feedback (Allsopp). Small-group instruction increased algebra students' self-confidence in a study conducted by Depree (1998). Students in the experimental group, who worked in small groups, had higher course completion rates, and the students indicated they benefited from the group work. However, Depree found no statistically significant differences between the experimental and control groups.

One approach that has shown promise of making algebra instruction more accessible to students with difficulties involves the use of concrete materials that develop into representational and eventually abstract thought. This approach is called the concrete-to-representational-to-abstract sequence of instruction (Mercer, Miller, & Witzel, 2003). This instructional model was used in Mercer et al.'s study for teaching algebraic transformation equations to 34 corresponding pairs of middle school students. The students were identified with risk factors that inhibit successful middle school mathematics performances that aid in the mastery of algebra concepts. Those factors included achievement level, age, pretest performance score, and classroom participation.

The concrete-to-representational-to-abstract process begins with a student using tangible objects (manipulatives) to model and explain mathematical problems. After students comprehend a concept concretely, they work with a similar concept using symbolic representations. Mercer et al. (2003) suggested that this model ensures student mastery of essential concepts for future algebra courses.

Thinking skills research. The use of thinking skills research in this study was essential to participating students' understanding of mathematical concepts necessary for readiness for an algebra course. The skill to employ reflective thought has been viewed in an array of ways: as a primary attribute of a well-informed person; as a prerequisite for accountable citizenship in a self-governing civilization; and, in more recent times, as an inclusive skill for an increasingly wide-ranging array of jobs (Cotton, 2001). Teaching children to develop into effective thinkers is increasingly recognized as a goal of education. Because students are a part of this highly technological society, they must be equipped to use lifetime learning and thinking skills needed to obtain and create information in a revolving civilization (Cotton).

Thinking skills are vital and are considered to be fundamental and highly developed skills in a person's intellectual processes (Cotton, 2001). However, Sormunen and Chalupa (1994) reported that thinking critically is not truly defined and is in its formative stages as more research becomes available. Both thinking and critical-thinking skills acquisition consists of obtaining knowledge and cognitive operations (Alvino, 1990). Cotton agreed with Sormunen and Chalupa that most instructional practices such as tutoring and using technology and training teachers to conduct thinking-skills instruction enhance student learning.

Sormunen and Chalupa (1994) described the emergence of theoretical perception in critical thinking in three models: (a) philosophical model, (b) psychological model, and

(c) educational model. In the philosophical model, students integrate their own thinking in the analytical process, whereas the psychological model is primarily focused on how and the ways students learn. The educational model integrates both models that are used in educational institutions. Students are encouraged to participate in higher order thinking, and learning is based on essential skills identified by the institution (Sormunen & Chalupa).

Cotton (2001) noted that thinking-skills instruction enhanced academic achievement. Cotton's research supported the use of specific techniques of study skills, creative and critical analysis, metacognition, and inquiry training in teacher instruction. According to Pogrow (1988), three instructional approaches improve the thinking skills of students: (a) redirecting, questioning, and reinforcing; (b) asking higher order questions; and (c) increasing wait time after a question has been posed by the teacher. Computer-assisted instruction also helps expand thinking skills (Cotton).

Eight-step instructional process and total quality management (TQM). The eight-step instructional process and TQM were mandated by the district in which this applied research study was conducted to assist in improvement efforts for all students. The district's goal was to have consistency in instruction among the schools. Davenport and Anderson (2002) provided training for leadership teams from each school in the district.

In Davenport and Anderson's (2002) research, 1,300 employees of Brazosport Independent School District believed they could teach every child and aid each one to attain higher levels of academic achievement. The schools in the district were performing poorly. After years of agonizing over the issue, the superintendent and director of instruction in the district analyzed state test scores closely by school, by teacher, and by student. The disaggregation of data revealed that students in a third-grade classroom in a poor-performing school showed remarkable mastery of essential concepts. District-level stakeholders met with the teacher, Barksdale, to obtain vital information about the instructional practices and strategies used in the classroom. The teacher's practices included researching each student's level of performance by administering a practice test as a preassessment, developing an instructional timeline based on the skills not mastered on the preassessment, using practice worksheets, and teaching and reteaching (Davenport & Anderson).

Davenport and Anderson (2002) explained that the teacher was tasked by the district to share this instructional process with colleagues at the elementary school in which she taught and implement a program for Grades 3–5. At the end of the school year during which the instructional process was utilized, the elementary school received an award for exemplary performance from the state. The students from that school made tremendous gains in mathematics and reading. The rationale of using this instructional process was based on a data-driven, cyclic uninterrupted development approach (Davenport & Anderson).

Davenport and Anderson (2002) utilized the Barksdale design; TQM; and the Plan, Do, Check, Act cycle to develop the eight-step instructional process: (a) test score disaggregation, (b) timeline development, (c) instructional focus, (d) assessment, (e) tutorials, (f) enrichment, (g) maintenance, and (h) monitoring. Davenport and Anderson noted several benefits to the eight-step instructional process. They included the ease of the process to adapt to any curriculum, promote culture, remove subjectivity, ensure that all state standards are taught, promote ongoing investigation, demonstrate proof of uniformity, and improve quality of instruction. The eight-step instructional process utilizes the philosophies of Deming and effective schools research (Davenport &

Anderson).

TQM is a set of organization practices intended for continuous improvement of any organization (Davenport & Anderson, 2002). These practices are based on Deming's 14 quality principles**,** which guide organizations through an improvement process. The Plan, Do, Check, Act cycle asserts that the primary beliefs that guide this practice must be established, maintained, and continuous for effective improvement to be evident (Rebore, 2004).

Cooperative learning. The researcher selected cooperative learning as an intervention based on its statistical effectiveness according to Gall et al. (2003). At the researcher's study site, cooperative learning is a practice used by teachers and supported by the administration. Cooperative learning is a system of instruction in which students work in small groups toward a common goal. Research (Zimbardo, 2003) has indicated that classrooms in which students support each other educationally can show dramatic performance gains; the total of their collaboration is greater than its individual parts. Research (Box & Little, 2003) also has shown that the use of cooperative learning groups in the classroom may positively affect student self-concept as well as academic achievement. The participating teachers used this research as basis for using cooperative learning groups to enhance student learning.

The structure of cooperative learning groups routinely consists of four members, where one is high achieving, two are average, and one is a low achiever. The groups are heterogeneously developed, taking into account ethnicity, gender, and ability (Nattiv, 1994). According to Nattiv, students educated in cooperative learning groups in comparison to other students in receipt of the same instruction in individualized formats learn equally or considerably greater. Classrooms in which students sustain each other educationally can help in performance improvements (Box & Little, 2003). Cooperative learning is mutual success through a collaborative effort, individual and group accountability, face-to-face interaction, and appropriate use of social skills (Breeden & Mosley, 1992). Student roles include group leader, recorder, encourager, evaluator, reader, and coordinator. The researcher employed the following five management ideas suggested by Nattiv when utilizing cooperative learning: (a) Students were held accountable for their conduct in groups, (b) students were responsible for active participation in groups, (c) students were ready to assist peers, (d) students asked for assistance from the teacher on the behalf of the team, and (e) students held each other in high regard.

VersaTiles Math Lab. The use of manipulatives was preferred in the classrooms of teachers at the study site. The president of the district chapter attended the NCTM conference, where a presentation on the use of VersaTiles Math Lab in the mathematics classroom was shared. The president redelivered the presentation and provided the district's mathematics teachers with a sample of the product. The researcher found the product to be interesting because of its unique way to assess students while engaging them in an enjoyable activity. Additionally, the researcher noticed that the sequence of the labs was similar to state standards and could be used to emphasize skills not mastered by students. The principal agreed to purchase a lab for each eighth-grade mathematics classroom.

VersaTiles Math Lab is an individualized mathematics programs for Grades K–8. However, each lab can be used for daily practice, learning centers, enrichment, mathematics remediation, and skill reinforcement (Lifeworks, 2000). This program is self-corrected and self-guided, in which lessons are grade explicit. In a review of this program, Ball (1999) noted that students who utilized this program in their school enjoyed the materials as they reinforced skills through practice in a multiple-choice format. She further stated that the program allows students to take ownership of their learning by maintaining a progression chart. The VersaTiles Math Lab encompasses practice concepts that range from basic operations to algebra, including the following five units: (a) Number and Number Concepts; (b) Estimation and Computation; (c) Patterns, Functions, and Algebra; (d) Geometry and Measurement; and (e) Statistics and Probability (Cooney, 2002).

Thomas and Thomas's (1999) problem-solving, collaboration, communication, connections, and reasoning (P3CR) activities. Thomas and Thomas, authors of *Dr. Thomas's P3CR Math Activities for Middle Grades*, provided training in the district where this study took place. Upon completion of the training, the teachers received a notebook of mathematics activities designed to focus students learning at the onset of a class period. The activities additionally are designed to maintain previously taught material. Thomas and Thomas's mathematics activities engage students in essential concepts with ease: problem solving, collaboration, communication, connections, and reasoning. The activities are designed to assist in increasing student involvement and promoting a positive classroom learning environment, where essential skills such as mental computation and problem solving are maintained. Thomas and Thomas noted that in order to successfully perform critical thinking in mathematics, students must have a thorough knowledge base. Computation skills comprise a significant part of a sound mathematical information base. Even though technology provides considerable support to the problem-solving process, students additionally need to be proficient in mental and paper-and-pencil mathematics skills (Thomas & Thomas). Thomas and Thomas suggested the utilization of a weekly progress method for data collection purposes.

Balka's (1995) Exploring Algebra and Pre-Algebra With Manipulatives. In 1995, Balka's resource book was issued to all algebra teachers upon completion of an algebra content course that was designed by the district's professional development department as an initiative to improve algebra instruction. The researcher has used the resource book to generate learning centers to reinforce algebraic concepts taught through direct instruction. Balka's book provides mathematics educators with mathematics labs that can be utilized in learning centers to provide practice and reinforcement for whole-group enrichment. The resource book also provides hands-on activities to engage students in discovery learning. Manipulatives are used to reinforce and model algebraic concepts as students move from a concrete operational level to an abstract, symbolic level. The students use a variety of objects to help them master essential mathematics and algebra concepts: two-color counters, dice, dominoes, cards, number or algebra tiles, and spinners (Balka).

Standards-based classroom learning. Standards-based classroom learning dominates the educational environment in an era of immense academic diversity in present-day classrooms (Tomlinson, 2000). This type of education refers to aligning academic content standards for what students should know and be able to do at each grade level in each subject. Students are assessed frequently to measure progress in achieving the standards, and schools are held accountable for their learning (Audent & Jordan, 2003; Chariho Regional School District, 2006). Standards-based learning has the following four key components: (a) clear, rigorous academic content standards; (b) support to advance teaching and learning; (c) reasonable and effectual assessments; and (d) accountability for results. Standards-based instruction that is differentiated according to the needs of students is used in these classrooms (Georgia Department of Education, 2006). Standards-based learning uses a progress-monitoring system to answer these questions in an effort to direct and fine-tune instruction (Georgia Department of Education, 2006).

Summary

Algebra is an intricate component to the advancement to higher level mathematics courses. It is suggested that students who do not take algebra are not likely to attend college (Pascopella, 2000). Middle school is a critical transitional phase for students' mathematical development that affects their high school performance in the subject (Sowder, 2003). Marzano (2003) suggested the use of researched-base instructional interventions by teachers to ensure mastery of essential concepts. Utilizing this thought as a framework for an instructional design will help middle school mathematics teachers develop effective lessons and employ practices that will contribute to student success in algebra at the ninth-grade level (Marzano, 2003).

The researcher used the works of Marzano (2003), Carpenter and Bottoms (2003), and Davenport and Anderson (2002) as the foundation in the development of this research study. The instructional intervention created by the researcher incorporated the use of the following seven strategies to help students achieve in mathematics: (a) peer tutoring (Allsopp, 1997), (b) thinking-skills activities (Cotton, 2001), (c) the eight-step instructional process (Davenport & Anderson), (d) cooperative learning (Zimbardo, 2003), (e) VersaTiles Math Lab (Lifeworks, 2000), (f) games and mathematics activities from *Dr. Thomas's P3CR Math Activities for Middle Grades* (Thomas & Thomas, 1999), and (g) the resource book *Exploring Algebra and Pre-Algebra With Manipulatives* (Balka, 1995). These instructional strategies were elected by the researcher based on literature for the purpose of improving state standards of participating students.

Based on research from California (Ezarik, 2002), the researcher proposed that improving students' mastery of state standards through eighth-grade prealgebra instruction would improve students' readiness for algebra at the ninth-grade level. The state-mandated Grade 8 mathematics objectives are divided into six domains with standards that support the skills necessary for success in algebra. The researcher aligned SREB readiness indicators with state standards as a basis for the development of an instructional sequence. Participating teachers used this instructional sequence along with researched-based strategies and an instructional process in the prealgebra classroom to teach the essential curriculum.

Chapter 3: Methodology

Overview

At least half of ninth-grade students failed algebra at a local, public high school, as evidenced by grades earned in the course and the fact that only 53% of these students met standards on the EOCT in 2005 (Georgia Department of Education, 2005). The vast majority of these freshmen attended middle school at the study site. This applied research study examined whether a planned intervention would improve the readiness of the participating eighth-grade prealgebra students for algebra at the ninth-grade level. Readiness was evaluated based on students' mastery of state standards (Georgia Department of Education, 2005) and their scores on the IAAT (Schohen, 1993). The goal of this applied dissertation was to develop, implement, monitor, and evaluate the results of an intervention designed to improve students' achievement on each mathematical domain as evidenced by the results of the CRCT and IAAT.

Participants

The initial participants were 309 students at the study site who were enrolled in eighth-grade prealgebra classes. Three students were placed in an alternative setting during the study; therefore, the number of participants was lowered to 306. Eighty-two percent of these students were African American, 14% White, 2% Hispanic, and 2% multiracial. All parents and students consented by signing the necessary documentation. The 4 eighth-grade prealgebra teachers (3 African American and 1 White) were participants in this study and responsible for teaching these students. Three teachers and the researcher served as the administrator and facilitators of the intervention. The teachers and researcher had an average of 12 years of experience; 1 teacher had secondary certification in mathematics education, and the other 2 teachers and the researcher were middle-school certified in mathematics. The researcher and 2 of the participating teachers have master's degrees, and 1 teacher has a bachelor's degree.

The researcher had been asked by the school principal to lead an initiative to develop and implement an instructional program designed to improve students' mastery of CRCT standards in an effort to advance their readiness for algebra at the ninth-grade level. The classes were heterogeneously grouped by gender, race, and ability in an interdisciplinary team setting. The students in this study were from diverse backgrounds in relation to socioeconomic status, because the school is a magnet school with both zoned students and students who choose to attend the school as well as NCLB students from schools assessed as in need of improvement.

Variables

The independent variable was a research-based instructional intervention developed by the researcher and designed to improve eighth-grade prealgebra participants' mathematics achievement based on research reviewed and discussed in chapter 2. The dependent variables were the participating students' scores on the CRCT in mathematics and the IAAT (algebra readiness indicator).

Design

This applied research study employed a pretest-intervention-posttest design, in which quantitative data were collected to measure participating eighth-grade prealgebra students' mastery of the state standards in mathematics, as evidenced by their performance on the CRCT, and readiness for algebra at the ninth-grade level, as evidenced by their performance on the IAAT. The CRCT and the IAAT were the instruments utilized for the pretest and the posttest.

Procedures

Davenport and Anderson’s (2002) eight-step instructional process provided the framework of the instructional design, because it is a district initiative to assist in improving students’ academic performance. Instructional practices and strategies, such as peer tutoring, graded homework, alternate assessments, and reinforcement, were used by teachers because they have been noted to have a positive impact on student achievement (Davenport & Anderson).

The use of the following seven research-based strategies was the foundation of the curriculum design implemented: (a) peer tutoring (Allsopp, 1997), (b) thinking-skills activities (Cotton, 2001), (c) the eight-step instructional process (Davenport & Anderson, 2002), (d) cooperative learning (Zimbardo, 2003), (e) VersaTiles Math Lab (Lifeworks, 2000), (f) games and mathematics activities from *Dr. Thomas’s P3CR Math Activities for Middle Grades* (Thomas & Thomas, 1999), and (g) the *Exploring Algebra and Pre-Algebra with Manipulatives* resource book (Balka, 1995). Many educational research studies are done to identify interventions, or factors that can be transformed into interventions, for improving students’ academic achievement (Gall et al., 2003). Wahlberg and various colleagues (as cited in Gall et al.) conducted a synthesis of the results of studies that correlated instructional methodologies and student learning. Interventions were identified from several studies and statistically assigned an effect size. Effect size is a quantitative technique of describing the level at which an average student receiving an intervention will perform in relation to an average student not receiving an intervention. The larger the effect size, the more powerful the intervention (Gall et al.). The interventions selected by the researcher have an effect size greater than 0.33 (Marzano, 2003).

On November 28, 2005, the researcher met with the 3 eighth-grade prealgebra teachers and invited them to participate in the study. All of them agreed and signed the appropriate consent forms. The researcher then discussed with the eighth-grade mathematics teachers the 2005 CRCT data (the analysis of which was vital), research-based strategies to be implemented, and the format for instruction during the intervention period. Also beginning on November 28, 2005, the researcher sent letters via U.S. mail to all the parents of potential student participants asking them to attend one of two parent workshops scheduled for December 7 at noon and December 8 at 4:00 p.m. The letters included parent and child consent forms. A total of 43 parents attended the workshops. Parents of students not attending either workshop submitted their consent form to participating mathematics teachers. Each teacher was responsible for collecting the documents and returning them to the researcher. About 30 parents did not return the consent forms. These parents were contacted by the researcher and home–school facilitator. Some home visits were made. All consent forms were signed and received by January 3, 2006.

On November 30, 2005, the researcher began the teacher training by reviewing the 2005 test results for the CRCT and discussing their implications. The researcher shared the research conducted by the SREB (Bottoms, 2000) and provided each teacher with a copy of the readiness indicators for algebra. These indicators had been aligned with the Grade 8 mathematics standards by the researcher in order to assist in determining an instructional sequence.

During December 2005, with the researcher's assistance, the teachers analyzed the CRCT data and prioritized standards in an effort to determine an instructional calendar for CTAG requirements. The instructional calendar indicated when standards were to be taught and for how long. The researcher introduced and explained the instructional design and the research-based strategies that were utilized in this study. The researcher modeled each strategy. In addition, the researcher provided teachers with graphing calculators and manipulatives to use in their mathematics classroom with students.

During December, the researcher and participating prealgebra teachers also took part in a school-wide book study based on the works of Marzano (2003). This was an effort to promote professional learning in the school, but the teachers viewed this activity as simply one more thing they had to do. However, upon completion of the book study, the participating teachers agreed that the information was very useful and insightful. For example, the teachers mentioned the concept of effect size and how Marzano (2003) related it to student achievement and specific instructional strategies proven to be successful. However, the participating teachers did not understand that some instructional strategies they used were ineffective. In reflective dialogue with the teachers at grade-level meetings, they admitted using strategies because of preference and convenience, not necessarily for effectiveness. The purpose of the book study should have been defined more clearly.

On January 3, 2006, the mathematics teachers administered a preassessment instrument (the IAAT) to the 309 participating eighth-grade students to measure algebra readiness. This took place in all eighth-grade prealgebra classes. Students were given 60 minutes to complete the test. After the teachers administered the IAAT, the tests were scored and stored in a secured area. The scores were shared with teachers and students and entered in the Statistical Package for the Social Sciences (SPSS) software.

Next, the teachers provided students with training on how to work in cooperative groups (January 4–6, 2006). Researchers (E. Cohen, 1994; Johnson, Johnson, & Houlbec, 1993; Stone, 1994) recommended the following three grouping techniques: (a) playing card method, (b) straw method, and (c) lottery method. These grouping techniques assisted the teachers in developing a sense of comfort for students and generating working relationships. At the onset of group work, the teachers discussed with the students the rules and expectations for them while working in cooperative groups. Establishing which social processing skills were emphasized, allocating a job to each group member, and introducing the learning task were the standard processes when working in cooperative groups. The function of the teachers was to observe, assist, and question participants while they worked (Johnson et al.).

While students were in cooperative groups, the teachers employed the think-pair-share and jigsaw cooperative learning strategies (Stone, 1994). The students participated in tasks that fostered thinking skills. Those tasks included the following three critical-thinking activities collected by the researcher from colleagues at past workshops: (a) license plate puzzles, (b) picture puzzles, and (c) initial puzzles (Kanter, Darby, & Toth, 1999). The researcher selected these tasks because they required the students to think critically using analyzing skills. The researcher found it necessary to utilize tasks that were not solely associated with mathematics. The goal was to get students to think and problem solve while in groups. Kanter et al.'s research supported the usage of such critical thinking tasks, because they assist in student learning of mathematics.

After the training was completed with the students, the teachers had a whole-group discussion with students about working in cooperative groups, where students were encouraged to share their feelings by using verbal and written communication. The researcher encouraged the use of reflection in an effort to get students to communicate their learning. This information was useful for instructional planning for future lessons.

Next, on January 9, 2007, the researcher and participating teachers began using the instructional format. This phase lasted 17 weeks. During this time, the teachers provided instruction following the prealgebra curriculum and using research-based strategies to aid in improvement of students' performance in each mathematics domain.

The format of instruction designed by the researcher was implemented in the nine classes. The classes met for 60-minute periods. The first 5 minutes of class consisted of a warm-up activity that connected to previous learning. The next 15 minutes were designated for instructional focus lessons as recommended by CTAG requirements: Step 3 in the eight-step instructional process (see Appendix B). The VersaTiles Math Lab was utilized during this timeframe because the activities related to the instructional calendar developed by the mathematics teachers. The lab contained five units: (a) Number and Number Concepts; (b) Estimation and Computation; (c) Patterns, Functions, and Algebra; (d) Geometry and Measurement; and (e) Statistics and Probability (Cooney, 2002). The VersaTiles unit topic (or standard) for the focus lesson was determined from data gathered from the 2005 Grade 8 mathematics CRCT scores. Standards were ranked from weakest to strongest based on the data. The state standards that most Grade 8 mathematics students did not meet on the CRCT took precedence on the calendar (Statistics and Probability, and Geometry and Measurement). The teachers allocated more time for reviewing those standards not met before beginning instruction on the eighth-grade standards to be assessed on the 2006 CRCT. After students completed a mathematics lab unit (related to the CRCT domain), a VersaTiles formal assessment (ETA/Cuisenaire, 2000) was administered to determine if further tutorial services were needed.

Four focus lessons were taught each week, beginning each Monday. On Fridays, a miniassessment (see Appendix C) was given to students on the identified focus for that week. The teachers scored assessments and placed stars on a progress chart for those students who scored 80% or higher. Another miniassessment was administered each Friday as a pretest for the following week's focus topic to allow the teachers to examine students' prior knowledge of skills for instructional planning purposes.

The rationale for testing weekly versus biweekly was based on the premise that advanced gains are made by students in skills essential for algebra when assessed more frequently (Kika, McLaughlin, & Dixon, 1992). Effective teachers realize the significance of ongoing assessments as the means to reach maximum performance (McTighe & O'Conner, 2005). This means that students are more apt to retain information when tested frequently, thus maintaining the skills needed to succeed in algebra. Performance on the miniassessment determined whether a student was placed in enrichment or remediation for the following week. Davenport and Anderson (2002) suggested that students mastering 80% on the weekly assessments receive enrichment or serve as peer tutors on days of reteaching. Davenport and Anderson suggested that students performing below 80% on weekly assessments receive tutorial services. Participating teachers teamed to offer tutorial services during Extended Learning Time, a 40-minute block of time designated for tutorial and enrichment, after school 2 days a week for 60 minutes. After completion of the tutorial sessions, the teachers administered a second assessment.

Based on 2004–2005 Grade 8 students' mathematics CRCT scores, the sequence for the focus lessons was in the following mathematical domain order: Weeks 1–7 addressed Statistics and Probability, and Weeks 8–17 covered Geometry and

Measurement. The units entitled Computation and Estimation and Problem Solving were ongoing and intricate components of the focus lesson development. Computation and Estimation and Problem Solving were mathematical domains that were reviewed and assessed weekly during direct instruction for maintenance, because they are a part of all of the domains.

The next 30 minutes of the class period were designated for direct instruction, wherein instruction and activities using state standards as the basis were conducted. Students were taught using whole-class instruction, cooperative groups, or individually. Teachers utilized the following seven instructional strategies identified by the researcher: (a) peer tutoring (Allsopp, 1997), (b) thinking-skills activities (Cotton, 2001), (c) the eight-step instructional process (Davenport & Anderson, 2002), (d) cooperative learning (Zimbardo, 2003), (e) VersaTiles Math Lab (Lifeworks, 2000), (f) games and mathematics activities from *Dr. Thomas's P3CR Math Activities for Middle Grades* (Thomas & Thomas, 1999), and (g) *Exploring Algebra and Pre-Algebra With Manipulatives* (Balka, 1995). Computer-assisted instruction and discovery learning where students problem solved, collaborated, communicated, made connections, and reasoned also were utilized in presenting the essential curriculum to students. The teachers instructed students following state standards from chapters 1–4 and 7–14 in the prealgebra textbook (Leschensky, 2001). Leschensky's nine topics were (a) tools for algebra and geometry, (b) exploring integers, (c) solving one-step equations and inequalities, (d) exploring factors and fractions, (e) solving equations and inequalities, (f) percents and proportions, (g) geometry, (h) polynomials, and (i) statistics and probability.

The last 10 minutes of class were used for debriefing and reflection (Bish & Dick, 1992). Bish and Dick noted that self-evaluation through reflection is vital in the learning process. The teachers summarized the material discussed for that day and reflected with the students on the activities conducted. The students were encouraged to maintain a journal to write their thoughts about the topic of discussion for that day and to demonstrate their learning. They also were encouraged to ask questions that related to any concepts presented that they did not understand.

The 2006 mathematics CRCT was administered on April 13, 2006, to assess students' mastery of state standards. The IAAT was administered to participating students on May 2, 2006, to measure their readiness for algebra and to statistically quantify growth and improvement. The scores were entered into SPSS to perform an independent-sample *t* test for statistical significance. The teachers also conducted reflective activities with participating students May 3–12, 2006. The teachers allowed students to write in their journals about their mathematics performance and how prepared they felt they were for an algebra course in ninth grade. The students also were encouraged to reflect over the past school year and to share mathematical experiences in their journals. Those students who were comfortable doing so were asked to share their thoughts verbally.

Group discussions with students were conducted. The teachers placed students in a circle to discuss what instructional strategies they enjoyed most and which strategies had the most impact on their mastery of standards. Nine participating students (1 from each prealgebra class) were selected to share their experience with seventh-grade mathematics students. The purpose of this reflective component was for students to have a level of collaboration and to focus on self-evaluation of their performance in the classroom (Bish & Dick, 1992).

Instruments

The first instrument used was the mathematics section of the CRCT, a state-mandated test. The state ensures that the CRCT is theoretically sound and developed to serve the intentional purpose by following national professional standards. Procedural and technological qualities are reviewed and monitored regularly by the state's testing division. All of the state's testing programs are submitted for review by the federal government, and educators' expertise is important in the development of such testing programs (Georgia Department of Education, 2006). Although no one test measures achievement with ideal validity or reliability, the state further noted that it was critical to consider the standard error of measurement when interpreting the scores obtained by students (Georgia Department of Education, 2006). Participating eighth-grade prealgebra students took this test in the spring of 2005. This test was used as a preassessment. This test was administered to students again in the spring of 2006 and used as a postassessment. The CRCT was implemented in 2000–2001 to measure students' performance on state standards. The mathematics component of the test contains six domains that consist of standards that students should have mastered throughout the school year. For the 2005–2006 school year, the CRCT was used to determine those eighth-grade students who would be promoted to the ninth grade (Georgia Department of Education, 2005). Students not obtaining a minimum score of 300 (out a maximum score of 450) had to attend summer school for remediation and were reassessed upon completion. These scores also were used by participating prealgebra teachers to make instructional decisions for participating eighth-grade prealgebra students.

The second instrument used was the IAAT (Schohen, 1993). The purpose of this instrument is to assist teachers and counselors to make the most knowledgeable decisions possible about the initial placement of students in a secondary mathematics curriculum (Schohen). Sabers (1968) studied the validity and reliability of the IAAT by using 1,943 eighth-grade students' scores on the test and their grades earned in mathematics. He found that the IAAT was a reliable (0.94) and, to some extent, a valid instrument for prediction purposes.

The IAAT was initially used to make recommendations for seventh-grade students' placement in an eighth-grade algebra course at the study site. The researcher used the instrument as a pre- and postassessment to measure the readiness for algebra of participating eighth-grade prealgebra students. The test had 63 multiple-choice questions divided into a four-part profile of students to permit the diagnosis of specific areas of strengths and weaknesses: (a) interpreting mathematical information, (b) translating to symbols, (c) finding relationships, (d) and using symbols. Obtaining a raw score of 46 (out of a possible 63) indicated readiness for algebra at the study site. The test was developed by researchers with a great deal of experience in mathematics education and in the construction of mathematics assessment devices (Monsaas, 1993).

Miniassessments were developed by participating eighth-grade prealgebra teachers as they correlated with the instructional focus calendar. These instruments were only used to assist teachers in making appropriate instructional decisions for students. They were not used to answer the research questions.

Data Analysis Strategy

Data from the 2005 CRCT pertaining to the participating students were analyzed by the school's eighth-grade prealgebra teachers, with guidance provided by the researcher, in order to develop an instructional calendar for focus lessons on state standards. Students' performance on the standards was ranked from weakest to strongest. The weaker mathematics standards were given higher priority on the calendar, and teachers thus spent more time on them. The teachers utilized the ranking of standards to determine the sequence of the focus lessons.

Miniassessments were administered weekly to assist in determining whether or not students mastered the standard taught during that week. Formal unit tests were also administered to students at the conclusion of each VersaTiles Math Lab unit (ETA/Cuisenaire, 2000). Data were analyzed from participants' performance on weekly miniassessments and formal assessments administered at the conclusion of each focus unit.

Spring 2006 CRCT performance by participating eighth-grade prealgebra students in each mathematical domain was compared with prealgebra students' performance on the 2005 CRCT utilizing an independent-sample *t* test. Lastly, the data collected from the IAAT pretest (January 3, 2006) were compared with the students' posttest (May 2, 2006) scores and analyzed using an independent-sample *t* test.

Summary

The purpose of this applied dissertation study was to develop, implement, monitor, and evaluate a research-based instructional intervention to improve eighth-grade prealgebra students' achievement and readiness for algebra. These standards are essential to students' readiness for an algebra course at the ninth-grade level (Ezarik, 2002).

Prior to the beginning of the study, the researcher met with participating eighth-grade prealgebra teachers to discuss the 2005 CRCT data, research strategies that would be used, and the instructional format utilized during the implementation phase of the intervention. During this time, the participating teachers administered the IAAT as a preassessment. The researcher then trained the participating teachers using research-based strategies on how to work in cooperative groups.

The implementation of the instructional format began in January 2006. The basic instructional schedule was warm-up activity (5 minutes), focus lesson (15 minutes), direct instruction (30 minutes), and debriefing (10 minutes). The researcher created a lesson plan template that was aligned with the basic instructional intervention for participating mathematics teachers to utilize (see Appendix D). The instructional intervention included research-based practices and strategies and weekly assessments for monitoring to aid in improving student achievement in mathematics.

The mathematics section of the CRCT was administered to students on April 13, 2006. The students also took the IAAT as a postassessment on May 2, 2006. In addition, the participating teachers conducted reflective activities with the students. These activities granted students an opportunity to communicate their learning and assisted teachers in making future instructional decisions. May 15, 2006, the researcher began to analyze all data pertinent to each research question. Results are presented in the next chapter.

Chapter 4: Results

Overview of the Intervention and Study

Two research questions guided this study. The first question examined whether or not an instructional intervention developed to assist eighth-grade prealgebra students would improve the students’ mathematics achievement, as evidenced by the percentage of students meeting or exceeding state standards on a state assessment. The second question explored whether the same instructional intervention would increase student readiness for algebra in ninth grade, as evidenced by the students’ performance on a readiness-for-algebra indicator test. The two instruments used in this study were the state CRCT and the IAAT.

Research Question 1

The first research question guiding this applied dissertation study was the following: Would an instructional intervention result in improved mathematics achievement of participating eighth-grade prealgebra students, as evidenced by an increased percentage meeting or exceeding the state standards, as measured by the CRCT, for each of the state domains (Number Sense and Numeration, Geometry and Measurement, Patterns and Relationships or Algebra, Statistics and Probability, Computation and Estimation, and Problem Solving), compared to the percentage who met or exceeded state standards the previous school year? The instrument used to collect these data was the CRCT, which was administered April 13, 2006. The mathematics section of the CRCT contained 60 questions that were based on six mathematical domains: (a) Number Sense and Numeration, (b) Geometry and Measurement, (c) Patterns and Relationships or Algebra, (d) Statistics and Probability, (e) Computation and Estimation, and (f) Problem Solving. The test was divided into two sections. Students were allowed 60 minutes to complete each section. No calculators were allowed.

Impact of the instructional intervention was measured by comparing the performance of participating students on the 2006 CRCT in each mathematical domain with that of a preintervention group. The preintervention group was Grade 8 prealgebra students not exposed to an instructional intervention, who attended the study site in 2004–2005. The overall percentages of students meeting or exceeding state standards in 2005 were compared to the percentages meeting or exceeding the state standards according to the 2006 CRCT results. Table 3 shows the percentage of students meeting or exceeding state standards as measured by the mathematics section of the CRCT in 2005, compared with the percentage of students meeting or exceeding the same standards in 2006.

Table 3

Comparison of Percentages of Grade 8 Prealgebra Students Meeting State Mathematics Criterion-Referenced Competency Test Standards by Domain

	% of students meeting standards by year	
Domain	2005	2006
Number Sense and Numeration	56	79
Geometry and Measurement	47	66
Patterns and Relationships/Algebra	57	73
Statistics and Probability	54	81
Computation and Estimation	55	82
Problem Solving	52	49
Average	54	72

Note. *N* for 2005 = 357. *N* for 2006 = 306.

The eighth-grade prealgebra participants in this applied research study showed improvement in five mathematical domains: (a) Number Sense and Numeration, (b) Geometry and Measurement, (c) Patterns and Relationships or Algebra, (d) Statistics and Probability, and (e) Computation and Estimation. One exception was the domain of Problem Solving. On the 2005 CRCT, 54% (n = 193) of the Grade 8 students enrolled in prealgebra met or exceeded state standards by obtaining a score of 300 or above. For the 2006 CRCT, 72% (n = 215) of the Grade 8 students enrolled in prealgebra met or exceeded state standards by obtaining a score of 300 or above. Both percentages included students with exceptionalities. Thirty-eight percent more Grade 8 prealgebra students met or exceeded state standards in mathematics on the 2006 CRCT, postintervention, than on the 2005 CRCT.

Table 4 shows a comparison of CRCT data. There was a statistically significant difference in participating students' mathematical performance on the 2006 CRCT in comparison to student performance on the 2005 CRCT.

Table 4

Comparison of Grade 8 Prealgebra Students Overall Mathematics Performance on the 2005 CRCT and 2006 CRCT

Year	No. of students	*M*	*SD*	*t*	*p*
2005	357	53.50	3.62		
2006	306	71.67	12.61	-3.391	0.007*

*$p < 0.01$

Research Question 2

The second research question guiding this applied dissertation was the following: Would an instructional intervention result in improved readiness of participating eighth-grade prealgebra students for algebra, as indicated by a higher postintervention percentage of participating prealgebra students obtaining a score of 46 or higher on the IAAT than the preintervention percentage? The instrument used to answer this research question was the IAAT. The instrument was designed to help teachers and administrators make determinations for algebra placement. Students were given 60 minutes to complete the four parts of the test (63 questions). The IAAT provides a four-part profile of students to permit the diagnosis of specific areas of strengths and weaknesses: (a) interpreting mathematical information, (b) translating to symbols, (c) finding relationships, (d) and using symbols. The researcher used this readiness-for-algebra indicator assessment as a pre- and posttest. The IAAT was administered to prealgebra students as a pretest on January 3, 2006, and as a posttest on May 2, 2006. After collecting the pre- and posttest results from the IAAT, the researcher compared the quantitative data utilizing SPSS Version 12.0.

The study site's raw score cut-off for performance on the IAAT was 46. On the IAAT pretest, 57 students scored a 46 or above (out of a maximum score of 63). On the IAAT posttest, 154 students scored 46 or above. Three students did not participate in the posttest because they were placed in an alternative setting. From pre- to postintervention IAAT, 97 more students obtained a score of 46 or above, which was a 178% increase in the number of students meeting or exceeding the criterion (see Table 5).

Based on the significant (one-tailed) t value of -13.945, $p = 0.000$, there was a statistically significance difference between participants' performance on the IAAT from pretest to posttest. The overall mean score from pretest to posttest improved by approximately 15 points. The posttest mean score (45.54) was just under the school's cut-off score of 46 (out of a maximum score of 63) to indicate readiness for algebra (see Table 6).

Table 5

Percentage of Grade 8 Prealgebra Students Meeting the Algebra Readiness Level on the Iowa Algebra Aptitude Test

Test	No. of students	% Meeting algebra readiness level
Pretest	57	18.0
Posttest	154	50.0

Note. Pretest $n = 309$; posttest $n = 306$. Algebra readiness level measured by a score of 46 or better (out of 63) on the test.

Table 6

Comparison of Grade 8 Prealgebra Participants' Pre- and Posttest Performance on the Iowa Algebra Aptitude Test

Test	No. of students	*M*	*SD*	*t*	*p*
Pretest	309	30.81	14.25		
Posttest	306	45.54	11.82	-13.945	0.000*

*$p < 0.01$

Table 7 shows students' average scores on each subtest of the IAAT. Students improved in all subtest areas. Although improvements were made in finding relationships and in using symbols, student performance was lower in these areas than in interpreting mathematical information and in using symbols. Overall, students showed improvements on the IAAT, but did not on average meet the required equivalent of 73% (a raw score of 46) to indicate readiness for algebra.

Miniassessment Data Analysis

Grade 8 prealgebra students were administered weekly miniassessments based on the essential curriculum topics on the instructional focus calendar. Eighth-grade prealgebra teachers taught these concepts during the initial 15 minutes of each class period. Preassessments were done at the onset of each calendar week. Miniassessments were administered on each Friday. The researcher compared the mean scores of participating eighth-grade prealgebra students (see Table 8).

Table 7

Comparison of Grade 8 Prealgebra Students' Average Performance on the Iowa Algebra Aptitude Test by Section

Test section	Pretest score	Posttest score
Part A: Interpreting mathematical information	67	83
Part B: Translating to symbols	47	91
Part C: Finding relationships	45	70
Part D: Using symbols	35	44
Average percentage	49	72

Table 8

Comparison of Grade 8 Prealgebra Participants' Performance on Miniassessments

Miniassessment	No. of students	*M*	*SD*	*t*	*p*
Preassessment	12	42.5	19.25		
Postassessment	12	66.7	13.71	-4.075	0.002

$^*p < 0.01$

Based on the significant (one-tailed) *t* value of -4.075, *p* = 0.002, there was a statistically significance difference between participants' performance on the miniassessments from pre- to postassessment. The overall mean score from pre- to postassessment improved by approximately 14 points. The results of the miniassessments are presented in Appendix E. These data illustrate that students improved in each topical area, except for customary and metric unit conversions.

Students not mastering 80% on miniassessments were placed in Extended Learning Time, 40-minute tutorial sessions, for 1 week to review the standard. Students were also provided an opportunity to receive tutorial services after school, 2 days a week for 60 minutes. After students received tutorial services, they were reassessed over the target standard. These results are presented in Appendix F. These data show the results of participating eighth-grade prealgebra students' performance on the second miniassessment administered by participating eighth-grade prealgebra teachers. Alternate teaching strategies were utilized and peer tutoring was employed. Initially, more students lacked mastery of the Pythagorean theorem. Forty-three of these students mastered the concept after receiving tutoring.

The Statistics and Probability and Geometry and Measurement domains (Weeks 5–12) were a priority on the instructional calendar, based on 2005 CRCT results. Data presented in Appendix G additionally show that the number of students placed in tutorial services for lack of mastery of Geometry and Measurement standards exceeded the number of students placed in tutoring services for lack of mastery in Statistics and Probability standards (Weeks 1–4). Even after a tutorial session on each target standard, not all students demonstrated mastery.

Summary

The researcher analyzed the data collected before and after the implementation phase to answer the research questions. Students' performance on the CRCT improved from 2005, when only 52% of the students met or exceeded state standards in mathematics, to 72% of the students meeting or exceeding state standards in 2006.

The participants in this study were also administered a readiness-for-algebra test, the IAAT. This readiness indicator test was used as a pre- and posttest. The required raw score to qualify for algebra at the study site was 46 (out of a possible 63). Eighteen percent of Grade 8 students obtained a 46 on the pretest, compared to 50% meeting this benchmark on the posttest.

Miniassessment data were analyzed by the researcher and participating teachers. Students not mastering 80% on a miniassessment were provided tutorial services and reassessed by their teacher. The findings indicated that some students, even after tutorial sessions, still lacked the mastery of the objective taught. Chapter 5 makes further recommendations to address the needs of those students.

Chapter 5: Discussion

Overview of the Applied Dissertation

The purpose of the applied dissertation was to develop, implement, and determine the effectiveness of an instructional intervention for eighth-grade prealgebra students. The intervention was designed to decrease the high number of students failing algebra in Grade 9, an existing problem at the high school that most of the students from the research site attended as well as in the school district. With NCLB (2002) legislation mandating accountability based on student performance and recent state requirements that students must participate in an EOCT for algebra upon completion of the course, it was critical to prepare Grade 8 prealgebra students for algebra by improving their performance on state standards in each mathematical domain. In 2004–2005, only 52% of students at the research site met or exceeded state standards in Grade 8 mathematics.

The first objective of the study was to develop an instructional intervention that would improve the mathematics achievement of eighth-grade prealgebra students, as indicated by an increase in the performance of these students on a state assessment (the CRCT), and improve their readiness for algebra, as evidenced by their performance on an indicator test (the IAAT). The following two research questions guided this study:

1. Would an instructional intervention result in improved mathematics achievement of participating eighth-grade prealgebra students, as evidenced by an increased percentage meeting or exceeding the state standards, as measured by the CRCT, for each of the state domains (Number Sense and Numeration, Geometry and Measurement, Patterns and Relationships or Algebra, Statistics and Probability, Computation and Estimation, and Problem Solving), compared to the percentage who met or exceeded state standards the previous school year?

2. Would an instructional intervention result in improved readiness of participating eighth-grade prealgebra students for algebra, as indicated by a higher postintervention percentage of participating prealgebra students obtaining a score of 46 or higher on the IAAT than the preintervention percentage?

The first research question was answered by comparing participating students' CRCT performance in mathematics in 2006 to students' mathematics CRCT performance from the previous school year, 2005. The researcher compared performance in each mathematical domain and used the SPSS software package to compare overall performance in an effort to determine if there was a statistically significant difference. There was; 38% more eighth-grade prealgebra students met or exceeded state standards in mathematics on the 2006 CRCT, postintervention, than on the 2005 CRCT.

The second research question was answered by comparing participating students' preintervention performance on the IAAT to their postintervention performance. The IAAT contains four subtest parts with a total of 63 multiple choice questions. The posttest was administered to participating Grade 8 prealgebra students at the study site on May 2, 2006. From pre- to postintervention IAAT, there was a 178% increase in the number of students meeting or exceeding the criterion. However, whereas students showed improvements on the IAAT, they did not on average meet the required score to indicate readiness for algebra.

During the month of December 2005, the researcher met with participating teachers to discuss the 2005 CRCT data, research-based strategies that would be used, and the instructional format utilized during the implementation phase of the intervention. With the researcher’s assistance, the teachers analyzed the CRCT data and prioritized standards to determine an instructional calendar for CTAG requirements. Each teacher developed miniassessments based on each instructional focus objective on the calendar. Participating teachers were honest about their lack of knowledge and skill in developing miniassessments that mirrored questions and format of the CRCT. The researcher met with the teachers to assist in this effort. Criteria for developing miniassessments were established by the researcher and the principal. Each miniassessment consisted of five multiple-choice questions; teachers were required to note the target objective on each miniassessment. Students needed to be aware of what was being assessed and to be able to communicate their learning. The researcher also identified resources to locate mathematics questions: the adopted mathematics book, CRCT coach books, and CRCT online resources. The teachers felt that this information was helpful and completed the task with ease as the researcher monitored and assisted in this process.

Additionally, the researcher met with teachers during their planning time and after school to discuss student achievement in mathematics and research-based instructional strategies that would be used in the classrooms. Teachers were given manipulatives such as a VersaTiles Math Lab, two-colored counters, playing cards, algebra tiles, algeblocks, geoboards, geometric solids, graphing calculators, and other resources to assist them in their instruction. Participating teachers welcomed any resources and ideas that might improve student achievement. Initially, teachers found it difficult to relinquish instructional practices that they had used for years, but they were willing to try something new to aid in improving students' mathematics performance on the CRCT. Improving student performance was required because of current accountability mandates from the school, district, and state. Teachers were very cooperative and expressed that they needed further guidance in the use of the manipulatives. During each grade-level meeting, the researcher and participating teachers shared how manipulatives could be used to enhance student achievement in mathematics. In addition to sharing during grade-level meetings, there was daily dialogue between the teachers and researcher to ensure effective usage and implementation. The researcher and participating teachers felt that continued collaboration was an important factor in implementation of this intervention.

Throughout the 2005–2006 school year, the researcher facilitated weekly meetings with participating teachers to discuss successes and failures of the instructional intervention, to facilitate future planning, to analyze miniassessment data, and to provide support. Four rules and procedures were set for weekly meetings: (a) Be on time; (b) stay on topic; (c) focus on student achievement; and (d) share one idea, activity, or strategy. The teachers were asked to describe their successes and failures in teaching prealgebra students and any stumbling blocks that prevented them from being successful in the classroom. The principal provided the researcher with a grade-level collaboration form (see Appendix G). These biweekly meetings were burdens for the teachers because of existing duties and responsibilities. However, they found the meetings to be beneficial because they learned additional instructional strategies and were free to express concerns that affected their professional growth. The researcher and participating teachers consistently explored solutions and supported each other through this process.

The preparation for this research study and the instructional intervention took place at the study site from November 28, 2005, through May 18, 2006. During this timeframe, the researcher and participating teachers implemented the instructional intervention developed by the researcher. The researcher monitored the intervention by assisting in administrative observations, reviewing lesson plans, and analyzing classroom data from miniassessments. The instructional focus calendar developed in December 2005 served as a guide for daily lessons. Participating teachers followed this calendar.

Pre- and postassessments were administered to participating students based on the objective to be taught according to the instructional focus calendar. During the first 15 minutes of each class period, the teachers used manipulatives and direct instruction to reinforce the critical objective for the week. Students not mastering objectives were placed in tutorial sessions with their mathematics teacher during Extended Learning Time. The teacher taught the critical objective again and reassessed the students for mastery. Students were also provided an opportunity to receive tutorial services after school.

During this intervention, teachers used several methods and strategies with students to facilitate their grasp of essential mathematics concepts with an effort to help them meet or exceed state standards while preparing them for algebra at the ninth-grade level. These methods or instructional strategies included the use of cooperative learning, VersaTiles Math Lab (Lifeworks, 2000), thinking research activities, peer tutoring, homework assignments, *Dr. Thomas's P3CR Math Activities for Middle Grades* (Thomas & Thomas, 1999), direct instruction, and discovery learning.

Findings from this study indicated that students learn by being actively engaged. The most effective strategies noted by participating teachers were the use of cooperative learning and VersaTiles Math Lab. Cooperative learning provided an opportunity for all students to learn and master the objectives taught by the teacher. According to the teachers, students enjoyed working with their peers and seemed to be less intimidated when they did not master skills. The teachers noted that the low achievers especially benefited from this strategy. In some instances, the teachers utilized cooperative learning in providing tutorials for those students who did not show mastery on miniassessments. According to researchers on cooperative learning (Slavin, Hurley, & Chamberlain, 2003), students who participate in small, well-structured learning teams achieve academically if there are clear team goals.

The most effective strategy noted by the researcher during reflective dialogue with participating teachers and students in this study was the use of the eight-step process (Davenport & Anderson, 2002), which required the implementation of an instructional focus at the onset of each class period. During this 15-minute timeframe, teachers used the VersaTiles manipulatives. The VersaTiles lessons were aligned with the instructional focus calendar. The students were engaged by working with the tiles to answer questions related to the featured objective for that week. Although instruction was provided when needed, the teacher's primary function during these periods was as a facilitator of learning. This hands-on activity was visual and granted students the opportunity to enjoy learning rather than just using paper and pencil. Initially, participating teachers had a difficult time understanding how to relate the instructional focus to content they already had to teach. The researcher clarified this by modeling an instructional focus lesson and showing how it could transition into the core lesson. After making that connection, teachers were able follow the instructional format with no difficulty.

The principal at the study site plans to implement this instructional strategy school-wide in the area of mathematics. Explorations have been undertaken to determine if and how this strategy can be adapted to other subject areas. During postplanning, on May 30, 2006, the researcher visited another middle school at the request of the principal to work with their Grade 8 mathematics teachers to implement this instructional intervention in 2006–2007. The teachers were receptive because they were faced with another year of being in need of improvement. In this session, the researcher introduced the instructional format and described the materials used. Also, the researcher modeled the use of VersaTiles Math Lab to teach essential concepts.

Implication of Findings

The purpose of this research study was to examine the impact a planned instructional intervention would have on Grade 8 prealgebra students' mathematics achievement, as indicated by their performance on a state assessment (the CRCT), and on their readiness for algebra, as evidenced by their performance on an indicator test (the IAAT). The findings from this study have two main implications concerning improving students' performance in mathematics.

First, the improvements made by participants in this study on the 2006 CRCT in comparison to the performance of a similar group of students the previous school year (2005) suggested that the use of this researched-based instructional design had a positive impact on student achievement in Grade 8 mathematics. A comparison of the CRCT results for the 2 years found the difference to be statistically significant. Seventy-two percent of the Grade 8 participating students demonstrated mastery of state standards in mathematics, compared to only 52% from the previous school year. Participants showed improvements in five of the six mathematical domains on the CRCT. Research-based strategies with a high effect size help students achieve (Marzano, 2003). Using hands-on activities and allowing participants to be active learners were central to the developmental parts of this instructional intervention that appeared to be beneficial to both teachers and students. Consistency and collaborative planning were evident. This finding supports Marzano's (2003) conclusion that providing teachers with an instructional outline that employs research-based strategies advances the academic achievement of students.

Marzano (2003) further noted that effectual pedagogy includes research-based strategies, good management techniques, and curricular design based on standards. It is essential that educators align standards with curricular content. This is based on the premise that students are held responsible on state evaluations for objectives within specific domains of knowledge (Flick & Lederman, 2002). There is a need for mathematics teachers to construct learning environments that mirror standards of curriculum and that lead to the achievement of all students (Flick & Lederman). Classrooms teachers who use an aligned, standards-based curriculum, while encompassing research-based strategies, transform a school into a successful one (Reeves, 1997).

Second, results from participating students' performance on the IAAT indicated that by providing teachers with a mathematics curriculum that is aligned with SREB algebra readiness indicators will improve students' readiness for algebra. Although differences between students’ scores on the pretest and posttest were statistically significant, half of the population did not meet the benchmark set by educators at the study site. According to the established criterion, these students were not ready for algebra at the ninth-grade level. This result suggests that other interventions are needed to ensure all students’ success in a higher level mathematics course.

Researchers in California concluded that districts needed more time to improve the quality of teaching before students could be held accountable to the higher standards (Ezarik, 2002). Ezarik noted that K–7 standards had to be properly implemented to transition students to algebra. Based on Ezarik’s research, the researcher proposed that improving students’ mastery of state standards through eighth-grade prealgebra instruction would improve students’ readiness for algebra at the ninth-grade level. This research supported the theory that using research-based instructional strategies in a middle school mathematics classroom will improve students' mathematics knowledge, as indicated by their performance on a state assessment.

Furthermore, the use of a planned instructional intervention that is consistent and standards based will positively impact student achievement in middle school mathematics. These findings support the works of Marzano (2003) and Ezarik (2002). Davenport and Anderson (2002) provided further insight into the management of such an instructional intervention. The eight-step process (Davenport & Anderson) provided the framework for this intervention, which was shown to be successful.

Limitations and Delimitations

The timeframe of the study limited the findings, because implementation of the intervention was for just one semester (18 weeks). Therefore, students' success in algebra in the ninth grade was not measured as part of this study. Participating students' performance in algebra at the ninth-grade level should be measured to further study the results of the intervention. Another limitation was the fact that the researcher was unable to monitor the ways in which or the extent to which the intervention was implemented in each classroom.

A delimitation was the fact that participants were limited to 3 teachers and 309 students. Also, the study was conducted at a relatively small middle school located in a small city in Georgia. Generalizations to different populations may not be made.

Recommendations

The following recommendations for further research were determined as a result of this research study:

1. Participating eighth-grade prealgebra students in this study should be tracked in ninth grade in an effort to further examine the impact of this intervention. A longitudinal

study with these students should be conducted. Intervention strategies should be explored further and evaluated to ensure the success of all the students.

Additionally, at the middle school level for students transitioning to high school, IAAT results can be useful for teachers, counselors, and parents in making decisions on student placement in mathematics courses at the ninth-grade level. There is also a need to conduct a correlation study to determine if the IAAT actually predicts success in algebra.

2. Teachers and students reflected upon the activities conducted in this study. They concluded that the most effective strategies used in this study were the use of cooperative learning groups and manipulatives. Utilizing this study as a framework, a study that examines the effectiveness of each of the instructional strategies used is recommended. Such a study could be used to determine which instructional strategies had the greatest impact on student achievement. Marzano (2000) identified 10 research-based, effective instructional strategies that positively influence student learning across content and grade levels. These strategies employ explicit implementation techniques. Research on which strategies work best for middle school students in mastering concepts essential for algebra should be explored and statistically measured for effectiveness.

3. School districts should offer staff development relative to using research-based strategies in mathematics classrooms. District officials should monitor this process and provide follow-up support, such as mentoring, observations, and opportunities for professional collaboration. A survey of 1,000 teachers indicated three features of staff development that have a strong impact on changing teacher behavior: (a) a focus on content, (b) an opportunity for active learning, and (c) consistency of staff development activities (Marzano, 2003). Staff development opportunities should provide teachers with simulated mathematical experiences in an effort to help them to deliver effective

instruction to students. Just providing teachers with mathematical resources is not enough; teachers need to be trained on how to use these resources so that they can successfully utilize them in their classrooms.

4. The researcher recommends that mathematics teachers embrace standards-based classroom learning. Standards-based classroom learning dominates the educational environment in an era of immense academic diversity in modern-day classrooms (Tomlinson, 2000). This type of education refers to the aligning of academic content standards for what students should know and be able to do at each grade level in each subject. Students are frequently assessed to measure progress in achieving the standards, and schools are held accountable for their learning (Chariho Regional School District, 2006). There are four key components of standards-based learning: (a) clear, rigorous academic content standards; (b) support to advance teaching and learning; (c) reasonable and effectual assessments; and (d) accountability for results. Standards-based instruction that is differentiated according to the needs of students is used in these classrooms (Georgia Department of Education, 2006). Teachers function as facilitators and are not the sole investors of learning. Students in a standards-based learning classroom are active learners and must produce authentic artifacts based on the standards being taught by the teacher (Georgia Department of Education, 2006). School improvement specialists in Georgia have recommended that standards-based classrooms have objectives and goals posted, and that teachers make reference to them while delivering instruction (Georgia Department of Education, 2006). Additionally, rules and procedures are posted and followed, and the use of Word Walls in the classroom plays a critical role in developing students' vocabulary and their understanding of the objectives in the curriculum. Standards-based learning classrooms are performance based, and the use of rubrics is

evident (Audent & Jordan, 2003; Chariho Regional School District).

Tomlinson (2000) indicated that students learn best when they can connect the curriculum to their lives. Therefore, further research is needed in this area to determine if using standards-based instruction and creating an environment based on standards improve student performance in mathematics. Educators should be interested in whether students are learning and how they are learning. Standards-based learning uses a progress-monitoring system to answer these questions in an effort to direct and fine-tune instruction (Georgia Department of Education, 2006). A future study can examine whether standards-based learning classrooms increase student achievement in mathematics.

5. High-stakes testing is currently debated at all levels of the educational organization (Amrein & Berliner, 2002). NCLB (2002) mandates accountability within these levels. Amrein and Berliner noted that high-stakes testing benefits teachers and students because they know what is important to learn and teach. Teachers need to be held accountable in an effort to motivate them to teach better, which will in turn motivate students to work harder and learn more.

Supporters of high-stakes testing maintain that this is a good measure of the curricula that are taught to students (Amrein & Berliner, 2002). High-stakes testing provides an equal opportunity for all students to demonstrate learning. Teachers utilize standard test results to assist in providing better instruction for individual students (Amrein & Berliner). Also, administrators use test results to improve student learning and to design staff development for teachers. Moreover, punishments are attached to high-stakes testing. Forty-five states hold schools accountable for their test scores by publishing school and district report cards. In California, administrators receive incentives for good test scores (Amrein & Berliner).

Future research should answer whether high-stakes testing positively impacts student achievement. In the state where this study was conducted, students in Grades 3, 5, and 8 must pass the CRCT in mathematics and reading to be promoted. Participants in this study were faced with this accountability. A future study similar to this one can assist in determining whether student achievement is a resultant of this mandate.

6. The researcher recommends the use of the Pyramid of Intervention developed by the Georgia Department of Education (2006). This intervention employs the use of standards-based instruction and the assessment of students for mastery. Students not mastering standards after tutorial opportunities are given an individualized plan of intervention, and a Student Support Team is developed. This team consists of the student, teachers, parents, counselor, and home–school facilitator. Stakeholders embracing this strategy will aid in all students mastering the essential curriculum (Georgia Department of Education, 2006).

7. Carpenter and Bottoms (2003) noted six essential actions to develop students' mathematical experiences: (a) Hire skilled teachers in the content area, (b) implement a curriculum that prepares students for advanced mathematics courses, (c) engage students in learning mathematics, (d) utilize real-world applications to teach mathematics, (e) create an environment that promotes high expectations, and (f) provide tutorial sessions for students. The researcher and participating teachers used five of the six essential actions as part of this intervention; hiring skilled teachers is the responsibility of the administrator at the study site. Utilizing these actions along with the eight-step instructional process (Davenport & Anderson, 2002) should help students improve their mathematics performance. This recommendation is supported by the statistically

significant findings in this study.

Summary

The researcher's goal was to improve eighth-grade prealgebra students' mathematics achievement and readiness for algebra at the ninth-grade level, as indicated by their performance on the CRCT, a state-mandated test, and on the IAAT, an algebra readiness assessment. The findings in this study affirmed an increase in student achievement as indicated by improvements in participating students' performance on the CRCT and IAAT. However, 28% of the participating students who were tested did not meet standards in mathematics on the 2006 CRCT. Therefore, further research and discussion are essential as they relate to standards and preparation of all students for algebra.

Based on the findings of this study, the researcher recommended that the participating students be tracked in Grade 9 to examine the impact of this intervention. Using this study as a framework, research should be conducted to examine further the effectives of the instructional strategies used in this intervention. The researcher believes that this study supported the assertion that there is a need for teachers to be provided professional learning opportunities in the use of effective instructional strategies and on how to effectively utilize manipulatives in the mathematics classrooms. Another recommendation is for mathematics teachers to use a standard-based curriculum, which is the first tier in the study state's Pyramid of Intervention (Georgia Department of Education, 2006). It is also recommended that research on the effectiveness of high-stakes testing on student achievement be conducted. The researcher finally recommends the use of Carpenter and Bottoms' (2003) six essential actions to develop students' mathematical experience in the classroom.

The researcher utilized the findings of this study to advance the school and district information base on student achievement in mathematics. Results from this study indicate that the use of research-based strategies along with a consistent instructional plan will positively impact students' achievement in mathematics.

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Appendix A

Readiness Indicator Alignment

SREB Readiness Indicators for Algebra Alignment With State Standards

Southern Regional Education Board (SREB) algebra readiness indicator	Grade 8 mathematics state standard domain	Grade 8 mathematics book and resource reference
1. Read, write, compare, order and represent in a variety of forms: integers, fractions, decimals, percents, and numbers written in scientific and exponential form.	Number Sense and Numeration Uses and recognizes the fundamental characteristics of numbers and number systems including ordering and their relation in fractional and decimal parts; understands development and use of place value in the base 10 system; and uses and recognizes the general descriptive properties of numbers.	Chapter 1: Lesson 4 and 5—Properties Chapter 2: Integers Chapter 4: Exploring Factors and Fractions Chapter 5: Lesson 1—Rational Numbers Chapter 6: Lesson 9—Scientific Notation Chapter 9: Ratios, Proportions, and Percents Chapter 13: Lesson 1—Finding Square Roots Dr. Thomas's Math Activities VersaTiles Math Lab Balka's Math Manipulatives
2. Compute fluently with integers, fractions, decimals, percents, and numbers written in scientific and exponential form, with and without technology.	Number Sense and Numeration Uses and recognizes the fundamental characteristics of numbers and number systems, including ordering and their relation in fractional and decimal parts; understands development and use of place value in the base 10 system; and uses and recognizes the general descriptive properties of numbers. Computation and Estimation Recognizes and uses the properties of addition and multiplication; recalls and uses basic facts; uses operations in computation and problem solving with whole numbers, fractions, decimals, and mixed numbers; uses estimation and mental computation strategies; and computes percents.	Chapter 1: Lessons 4 & 5—Properties Chapter 2: Integers Chapter 4: Exploring Factors and Fractions Chapter 5: Lesson 1—Rational Numbers Chapter 6: Lesson 9—Scientific Notation Chapter 9: Ratios, Proportions, and Percents Chapter 13: Lesson 1—Finding Square Roots Chapter 13: Lesson 3—The Real Number System Dr. Thomas's Math Activities VersaTiles Math Lab Balka's Math Manipulatives Assessment: Research report on number systems
3. Determine the greatest	Number Sense and Numeration	Chapter 4: Exploring Factors and

Southern Regional Education Board (SREB) algebra readiness indicator	Grade 8 mathematics state standard domain	Grade 8 mathematics book and resource reference
common factor, least common multiple, and prime factorization of numbers.	Uses and recognizes the fundamental characteristics of numbers and number systems including ordering and their relation in fractional and decimal parts; understands development and use of place value in the base 10 system; and uses and recognizes the general descriptive properties of numbers.	Fractions Dr. Thomas's Math Activities VersaTiles Math Lab Balka's Math Manipulatives Assessment: Factor tree mobile
4. Write and use ratios, rates, and proportions to describe situations and solve problems.	Patterns and Relationships/Algebra Identifies number relations; predicts and completes patterns; determines missing terms and rules for given patterns; recognizes, describes, and generalizes patterns and sequences; identifies and uses variables; uses order of operation to simplify and evaluate expressions; writes and solves equations; and graphs inequalities. Problem Solving Interprets data and constructs appropriate graphs; understands and solves problems using problem-solving strategies; and analyzes situations to determine appropriate strategies and/or solve problems.	Chapter 9: Ratios, Proportions, and Percents Dr. Thomas's Math Activities VersaTiles Math Lab Balka's Math Manipulatives Cooperative Learning Assessment: Shopping activity; make a cookbook
5. Draw with appropriate tools and classify different types of geometric figures using their properties.	Geometry and Measurement Uses and recognizes the fundamental characteristics of shapes, including sorting and classifying plane and solid figures; uses appropriate units and instruments in measuring; and uses formulas related to plane and solid figures.	Chapter 2: Lesson 2—The Coordinate System Chapter 3: Lesson 5—Perimeter and Area Chapter 7: Lesson 4—Circles and Circumference Chapter 7: Lesson 8—Using the Metric System Chapter 11: The Language of Geometry Dr. Thomas's Math Activities VersaTiles Math Lab Assessment: Geometry picture dictionary

Southern Regional Education Board (SREB) algebra readiness indicator	Grade 8 mathematics state standard domain	Grade 8 mathematics book and resource reference
6. Measure length with appropriate tools and find perimeter, area, surface area, and volume using appropriate units, techniques, formulas, and levels of accuracy.	Geometry and Measurement Uses and recognizes the fundamental characteristics of shapes, including sorting and classifying plane and solid figures; uses appropriate units and instruments in measuring; and uses formulas related to plane and solid figures.	Chapter 12: Area, Surface Area, and Volume Dr. Thomas's Math Activities VersaTiles Math Lab Assessment: Geometry storybook problems
7. Understand and use the Pythagorean relationship to solve problems.	Patterns and Relationships/Algebra Identifies number relations; predicts and complete patterns; determines missing terms and rules for given patterns; recognizes, describes, and generalizes patterns and sequences; identifies and uses variables; uses order of operation to simplify and evaluate expressions; writes and solves equations; and graphs inequalities.	Chapter 13: Lesson 4—Pythagorean theorem Dr. Thomas's Math Activities VersaTiles Math Lab Assessment: Participation in a math lab proving the theory (see math book).
8. Gather, organize, display and interpret data.	Statistics and Probability Collects and organizes data; determines appropriate method to display data; interprets and draws conclusions from data; determines probability of events; identifies outcomes of events; and finds and uses mean, median, mode, and range.	Chapter 1: Lesson 10—Gathering and Recording Data Chapter 6: Lesson 6—Measures of Central Tendency Chapter 8: Lesson 2—Scatter Plots Chapter 9: Lesson 6—Using Statistics to Predict Chapter 10: Statistics and Probability Chapter 11: Lesson 2—Making Circle Graphs Dr. Thomas's Math Activities VersaTiles Math Lab Assessment: Make a household budget circle graph from a set of data.
9. Determine the number of ways events can occur and the associated probabilities.	Statistics and Probability Collects and organizes data; determines appropriate method to display data; interprets and draws conclusions from data; determines	Chapter 10: Statistics and Probability Chapter 12: Lesson 3—Geometric Probability

Southern Regional Education Board (SREB) algebra readiness indicator	Grade 8 mathematics state standard domain	Grade 8 mathematics book and resource reference
	probability of events; identifies outcomes of events; and finds and uses mean, median, mode, and range.	Dr. Thomas's Math Activities VersaTiles Math Lab Assessment: Utilize the computer Excel program to analyze a set of data.
10. Write, simplify, and solve algebraic equations using substitution, the order of operations, the properties of operations and the properties of equality.	Patterns and Relationships/Algebra Identifies number relations; predicts and complete patterns; determines missing terms and rules for given patterns; recognizes, describes, and generalizes patterns and sequences; identifies and uses variables; uses order of operation to simplify and evaluate expressions; writes and solves equations; and graphs inequalities.	Chapter 1: Lesson 2—Order of Operations Chapter 1: Lesson 6—Variables and Equations Chapter 1: Lesson 8—Solving Equations using the Inverse Operation Chapter 3: Solving Equations and Inequalities Chapter 7: Solving Multi-Step Equations and Inequalities Dr. Thomas's Math Activities VersaTiles Math Lab Balka's Math Manipulatives
11. Represent, analyze, extend, and generalize a variety of patterns.	Patterns and Relationships/Algebra Identifies number relations; predicts and complete patterns; determines missing terms and rules for given patterns; recognizes, describes, and generalizes patterns and sequences; identifies and uses variables; uses order of operation to simplify and evaluate expressions; and writes and solves equations and inequalities.	Chapter 2: Lesson 6—Look for a Pattern Chapter 5: Lesson 9—Arithmetic Sequences Chapter 6: Lesson 8—Geometric Sequences Assessment: Make a tessellation.
12. Understand and represent functions algebraically and graphically.	Patterns and Relationships/Algebra Identifies number relations; predicts and complete patterns; determines missing terms and rules for given patterns; recognizes, describes, and generalizes patterns and sequences; identifies and uses variables; uses order of operation to simplify and evaluate	Chapter 8: Lesson 1—Relations and Functions Chapter 8: Lesson 3—Graphing Linear Relations Chapter 8 : Lesson 4—Equations as Functions Chapter 8: Lesson 6—Slope Assessment: Calculate slope graphically and algebraically in

Southern Regional Education Board (SREB) algebra readiness indicator	Grade 8 mathematics state standard domain	Grade 8 mathematics book and resource reference
	expressions; writes and solves equations; and graphs inequalities.	math journal.

Appendix B

Sample of a Focus Lesson Plan

Focus Lesson Plans for Week 1

Materials: VersaTiles Math Lab Kit (Tiles and Workbooks)

Day 1 (Monday)

VersaTiles Lesson Title: “In the Mode” Page 6

Objective: Find the mode of a set of data.

Day 2 (Tuesday)

VersaTiles Lesson Title: “Growing and Growing” Page 9

Objective: Use data from a line plot to solve a problem.

Day 3 (Wednesday)

VersaTiles Lesson Title: “Averages” Page 19

Objective: Find the mean of a set of data.

Day 4 (Thursday)

VersaTiles Lesson Title: “You can Count on it” Page 21

Objective: Use a tree diagram to determine the number of outcomes based on a spinner, number cube, or coins.

Day 5 (Friday)

Miniassessment will be administered for Week 1 focus. An assessment for Week 2 focus will be administered as a preassessment for instructional planning.

Appendix C

Sample of a Miniassessment

Miniassessment for Weeks 1 and 2

Student Name: ____________________ Date: ____________ Class Period: __________

Domain: Statistics and Probability
Standard: Determines probability of events and identifies outcomes of events. Finds and uses mean, median, mode, and range. Determines the appropriate method to display data.

Read each question and choose the best answer. Then write the letter for the answer you have chosen in the blank at the right of each question.

1. A green number cube and a red number cube are rolled at the same time. What is the probability of rolling a 5 on the green cube and a number less than 3 on the red number cube? 1 __________

A. ½ B. 1/12 C. 1/3 D. 1/18

2. There are 48 cards in a deck of animal game cards. What is the probability of selecting a zebra card at random if there are 4 zebra cards in the deck? 2 ___________

A. ½ B. 1/12 C. 1/6 D. 1/48

3. Katie bought a bag of 400 assorted colored jellybeans. Only six of the jellybeans were red. What percent of the assorted jellybeans were red? 3 ___________

A. 1.5% B. 3% C. 6.6% D. 3.5%

4. Fine the median and range of these measurements: 32in, 38in, 30in, 34in, 39in, 36in 4 ___________

A. 35 in and 9 in
B. 34 in and 2 in
C. 34.6 in and 8 in
D. 33.5 in and no range

5. If you drew a scatter plot of science scores of seventh grade students and the amount of study time, what type of line of best fit would you expect? 5 ___________

A. a line with positive slope
B. a line with negative slope
C. a horizontal line
D. a vertical line

Score:_____________ Tutorial services needed __________________

Appendix D

Intervention Lesson Plan Template

Lesson Plan Template

<table>
<tr><td colspan="2">Teacher's Name:</td><td>Grade: 8</td><td>Week of:</td></tr>
<tr><td colspan="4">Day:</td></tr>
<tr><td>Domain</td><td colspan="3"></td></tr>
<tr><td>RATIONALE</td><td colspan="3"></td></tr>
<tr><td>STANDARD(S) and ELEMENT(S)</td><td colspan="3"></td></tr>
<tr><td>OBJECTIVE(S)
(begins with thinking words)</td><td colspan="3">The students will:</td></tr>
<tr><td>ASSESSMENT</td><td colspan="3"></td></tr>
<tr><td>MATERIALS</td><td colspan="3"></td></tr>
<tr><td>WARM-UP ACTIVITY (5 min)
(connects to previous learning)</td><td colspan="3"></td></tr>
<tr><td>MINI-LESSON
Instructional Focus
(10 min)</td><td colspan="3"></td></tr>
<tr><td>WORK/ACTIVITY PERIOD (30 min)</td><td colspan="3"></td></tr>
<tr><td>SUMMARY
(Reflection)
(10 min)</td><td colspan="3"></td></tr>
</table>

Appendix E

2006 Weekly Miniassessment Data

2006 Weekly Miniassessment Data

Topic	Pretest score	Posttest score
Week 1: Stem-and-leaf plots/mean, median, and mode	55	75
Week 2: Scatter plots/simple and compound events	60	65
Week 3: Collects and organize data	40	85
Week 4: Bar, line, and circle graphs	50	55
Week 5: Coordinate plane/circumference	30	65
Week 6: Customary and metric units	45	40
Week 7: Plane and solid geometric figures	30	55
Week 8: Labeling geometric figures	25	70
Week 9: Similarity and congruency/triangles	35	60
Week 10: Pythagorean theorem	10	75
Week 11: Area and volume	45	65
Week 12: Classifying angles	85	90

Appendix F

Second Miniassessment Data

Topic	No. of students	Average score	No. of students with 80% or higher on second miniassessment
Week 1: Stem-and-leaf plots/ mean, median, and mode	75	75	58
Week 2: Scatter plots/simple and compound events	67	60	55
Week 3: Collects and organize data	58	80	50
Week 4: Bar, line, and circle graphs	30	90	29
Week 5: Coordinate plane/circumference	42	85	30
Week 6: Customary and metric units	90	55	41
Week 7: Plane and solid geometric figures	59	60	10
Week 8: Labeling geometric figures	66	75	45
Week 9: Similarity and congruency/triangles	38	80	20
Week 10: Pythagorean theorem	101	70	43
Week 11: Area and volume	45	90	24
Week 12: Classifying angles	20	90	20

Appendix G

Grade-Level Meeting Form

GRADE-LEVEL MEETING

DATE ___________________ SUBJECT __________________ GRADE_____

Members Present:

____

____

____

Members Absent:

____

____

____

REFLECTION OF LAST WEEK
What things went well for you last week? What stumbling blocks did you have? How did the students perform on the assessment(s)?
(These are some examples of questions to ask to get the conversation started. Each team member should be given an opportunity to respond, and comments should be recorded below. Also, suggestions should be given as to how one might teach a lesson differently that he/she had difficulty with).

COMMENTS:____
____
____
____
____
____
____

THIS WEEK'S FOCUS
The topics for this week are:
____
____

How are things going? Are you experiencing any stumbling blocks that you did not foresee?

COMMENTS:____
____
____
____
____
____
____

WHERE WE'RE HEADED
The topics for next week are:

____

____

What are some teaching strategies or activities that you will use for these topics? What types of manipulatives will you use?

COMMENTS:____

____

____

____

____

____

____

ASSESSMENTS
(Students need to be assessed in a variety of ways, such as paper/pencil tests, projects or performance-based tasks, writing prompts, and orally. These assessments should be developed before the lesson is taught, and they should be common among team members. Fill in below information about the assessments that the group will be using next week).

Paper/pencil Test(s):____

Project(s):____

Writing Prompt(s):____

Oral Assessment(s):____

Other Assessment(s):____