THE EFFECTIVENESS OF TWO MATHEMATICAL INSTRUCTIONAL PROGRAMS ON THE MATHEMATICS GROWTH OF EIGHTH GRADE STUDENTS

by

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(Under the Direction of William W. Swan)

ABSTRACT

The purpose of this study was to determine if there would be a significant difference in the achievement levels of two groups of eighth grade students when one group received instruction from a Saxon Mathematics Program, and the other group received instruction from a Pre-Algebra Program. Four schools in Georgia participated in the study. Marietta Middle School in Marietta City and Warner Robbins Middle School in Houston County received the Saxon Mathematics Program, and Smitha Middle School in Cobb County and Chestnut Log Middle School in Douglas County received the Pre-Algebra Program. The student sample consisted of 994 eighth grade students in the four middle schools. The independent variable was the instructional approach. The dependent variables were the student scores of the subtest of the Eighth Grade Iowa Test of Basic Skills – Mathematics Total, Concepts and Estimation, Problems and Data Interpretation, and Computation – with the Georgia Criterion Referenced Competency Test (CRCT) serving as the covariate. The analysis of covariance was used to determine statistical significance of the main effects – instructional approach, gender, and ethnicity/race – and the interactions between and among instruction, gender, ethnicity/race.

The results of this study showed that non-white male and white female students benefited the most from the Saxon Mathematics Program in all four dependent variables – Mathematics Total, Concepts and Estimation, Problems and Data Interpretation, and Computation. The white male benefited from the Saxon Mathematics Program in three of the subtests – Mathematics Total, Concepts and Estimation, and Computation- and scored higher in Problems and Data Interpretation using the Pre-Algebra Program. The non-white female scored higher using the Pre-Algebra Program on three of the subtests-Mathematics Total, Concepts and Estimation, and Problems and Data Interpretation. All students scored higher on the Computation Subtest using the Saxon Mathematics Program.

INDEX WORDS: Saxon Mathematics Program, Pre-Algebra Program, Basic Skills, Reform Mathematics, Constructivist

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DEDICATION

This dissertation is dedicated to my parents who instilled in me “a love for learning” and an attitude to never give up on my goals, and also to my husband, Don, for his love and support throughout the process of my completing the doctoral program at The University of Georgia.

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CHAPTER 1

INTRODUCTION TO THE STUDY

In the United States today, mastering mathematics has become more important than it was years ago. Students with a strong grasp of mathematics have an advantage in academics and in the job market (Riley, 1998). As technology becomes more prevalent in the work place, workers will need to have strong backgrounds in mathematics to help maintain the U.S. international competitiveness (Riley, 1998). Mathematics has always claimed a position at the core of education. In the 1960s, attempts to change the nature and teaching of mathematics gained national attention, and the age of new mathematics began. Those attempts at change failed to have an immediate effect on student learning (Association for Supervision and Curriculum Development, 1999). Throughout the 1980s, there was a renewed focus on student performance, both nationally and internationally (Schmidt, McKnight, & Raizen, 1997). Comparative studies, such as the Second International Mathematics Study (SIMS), showed that U.S. students performed considerably worse than students in countries considered to be our economic peers (ASCD, 1999). This raised questions about the mathematics curriculum and expectations for student performance. In 1989, the National Council of Teachers of Mathematics (NCTM) released a set of curriculum standards that were based on research about learning and teaching (ASCD, 1999). The idea of consensus standards for school subjects was a new one that was greeted by most of the public with acceptance. It was not clear how many teachers incorporated these standards into their vision/mission of teaching.

In 1989, President Bush and the state's Governors created the National Education Goals Panel and adopted six goals for education, including one that specifically placed American education in a global context by stating that ". . . U. S. students will be first in the world in math by the year 2000. . ." (Bush, 1990, pp. 147-148). Unfortunately, students' performance in international assessments during the 1990s did little to ease the governors' concerns (Haycock, 2002). "First in the world" was an empty slogan that was not met but was the level of performance necessary to maintain American preeminence in an internationally competitive economy (U. S Department of Education, 1997). In order to remain competitive, Americans had to be among the most skilled in the world (Business Coalition for Educational Reform, 1998). The Glenn Commission Report, *Before Its Too Late* (The National Commission on Mathematics and Science Teaching, 2000) reinforced this goal for students to become competent in mathematics by listing the following four reasons:

1. Rapid change in the global economy: demands for skills in reasoning, researching, and problem-solving in the workplace are increasing.
2. Everyday decision-making: citizens need to understand and make reasonable decisions related to such matters as cloning, DNA evidence in legal cases, new drugs, global warming, ozone-layer destruction, and financial situations.
3. National security: the safety of our citizens and the preservation of our freedom are an ongoing national goal and responsibility.
4. Future progress: mathematics and science help as understand our world; they are the tools for improving our lives. (p. 9)

Accomplishing this goal created the need for an assessment model both to monitor the U.S. progress relative to other nations and to examine other educational systems for exemplary practices that could be used here. Within the United States, the best source of information on the achievement of the United States students was the National Assessment of Educational Progress (NAEP, 2003). This was a federally mandated survey that determined what students knew about mathematics (National Council of Teachers of Mathematics, 2000). The 1995 International Mathematics and Science Study (TIMSS) was designed to measure the mathematics and science performance of United States students in comparison to their peers in 40 other countries at 3 different grade levels (U.S. Department of Education, 2001). The 1999 Third International Mathematics and Science Study-Repeat (TIMSS-R) was a successor to the 1995 TIMSS and focused on the mathematics and science achievement of eight-grade students in 38 nations. TIMMS-R allowed the United States to compare the achievement of its eighth-graders four years later (U.S. Department of Education, 2001). TIMSS-R included a videotape study of eighth-grade mathematics and science teaching in seven nations which provided information as to how the countries differed in what they taught, the way they taught, and how they overcame obstacles to student learning. As a result, the TIMSS's were some of the major international education surveys of the 1990s (U. S. Department of Education, 2001).

The results of TIMSS were encouraging with respect to the state of elementary mathematics education. Third and fourth graders in the United States scored above average, while seventh and eighth graders scored below average, and twelfth graders scored well below average. Evidence showed that United States middle school students had not improved in mathematics relative to the other nations over the past three decades. These findings reinforced concerns about the conditions of middle and high school mathematics education. The TIMSS documented several factors that contributed to the differences between scores at the fourth and eighth grade levels. One of these factors was the mathematics curriculum. Typical United States curriculum included many more topics than curriculums of other countries, which resulted in an unfocused curriculum (Schmidt, et al., 1997). United States students fell back in grades five through eighth because of the overloading of concepts and lack of depth in any one concept. In contrast to the TIMSS results, the domestic story in mathematics achievement offered some encouraging news. Over the 1990s, results on the National Assessment of Educational Progress (NAEP) in mathematics have significantly improved (U. S. Department of Education, 1999). At every grade level tested and for every group, student performance at the close of the decade was stronger than it was at the beginning. Despite these gains, American students are not progressing far enough (Haycock, 2002). Research indicated the need for increased academic expectations for all students and for a major re-tooling of curriculum and instruction in mathematics education.

Problem Statement

The problem of this study was to examine middle school mathematics curriculum to determine the effectiveness of a Saxon Mathematics Program that emphasized a basic curriculum and a Pre-Algebra Program that emphasized a reform curriculum on middle school students' knowledge and skills in mathematics. Considering the emphasis of the *No Child Left Behind Act* (U.S. Department of Education, 2002) on using research-based practices and accountability and the emphasis of the *A Plus Education Reform Act* (as amended in 2003) on accountability for disaggregated groups, examining mathematics is crucial to providing the most effective instruction to students.

Purpose of the Study

The purpose of this study was to determine the effects of Saxon Mathematics, which emphasized the basics, as compared to a Pre-Algebra program that emphasized reform curriculum on middle school students over a three-year period (6^{th} grade to 8^{th} grade). Four urban middle schools were selected. The two schools using the Saxon Mathematics were Marietta Middle School in the Marietta City School System and Warner Robbins Middle School in Houston County. The two schools using the Pre-Algebra program were Smitha Middle School in Cobb County and Chestnut Log Middle School in Douglas County.

Research Questions

There were three research questions for this study as follows:

1. Are there statistically significant differences in student mean achievement scores on the Iowa Test of Basic Skills (ITBS) in mathematics (Total Score, Concepts and Estimation Subtest Score, Problems and Data Interpretation Subtest Score, and Computation Subtest Score) (adjusted by student scores on 6^{th} grade CRCT Mathematics test) for 2002-2003 for eighth grade students being instructed with the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools ?
2. Are there statistically significant differences in student mean achievement scores on the ITBS in mathematics (Total Score, Concepts and Estimation

Subtest Score, Problems and Data Interpretation Subtest Score, and Computation Subtest Score) (adjusted by student scores on the 6th grade CRCT Mathematics test) for 2002-2003 between males and females of those eighth grade students being instructed with the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools for three years?

3. Are there statistically significant differences in student mean achievement scores on the ITBS in mathematics (Total Score, Concepts and Estimation Subtest Score, Problems an Data Interpretation Subtest Score, and Computation Subtest Score) (adjusted by student scores on 6th grade CRCT Mathematics test) for 2002-2003 between non-white and white students being instructed with the Saxon mathematics Program in two middle school for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools for three years?

Importance of the Study

In 2002 President Bush signed into law the *No Child Left Behind Act of 2001* (NCLB). This act gave the schools and the country the most significant groundbreaking educational reform in many years. One of the four basic reform principles in the NCLB is the emphasis given to scientifically-based research on teaching methods that have been proven to work. Mathematics educators have sought research-based materials that could be used to teach all the students. Debates about what should be taught in mathematics and how it should be taught have degenerated to “math wars” (Hoff, 2002a). On one side are those who fervently believe children need to learn the basics, and on the other side are those who believe that students should become mathematical problem-solvers who can communicate and reason mathematically. Knowledge gained from this study of the Saxon Mathematics Program that uses a traditional teaching model of the basics and the Pre-Algebra Program that uses a constructivist teaching model of reform on student achievement was valuable in assessing what mathematics programs in Georgia were getting results under what conditions. This study added to the limited number of instructional studies of mathematics curriculum.

Limitations of the Study

The results of this study may be generalized only to schools using a middle school model which are using the Saxon Mathematics Program and the Pre-Algebra Program and which are demographically similar to the four schools studied.

Organization of the Remainder of the Study

Chapter 1 included an introduction to the performance of U.S. students in mathematics, the Purpose of the Study, Research Questions, Importance of the Study, and Limitations of the Study. Chapter 2 is a review of the literature as it relates to the four mathematics teaching models. It focuses on the two models that relate to the traditional teaching of basics in Saxon mathematics and the constructivist teaching model of reform in the Pre-Algebra Program and its effects on student achievement. The review also includes a history of Saxon mathematics, Georgia’s involvement with Saxon mathematics, Saxon teaching methods, and a summary. Chapter 3 provides a description of the methodology of the study. It includes the sample/population from the four middle schools, instrumentation, procedures, reliability of the instrument, data analysis, and a summary. Chapter 4 presents the data and an analysis of the findings. Chapter 5 contains the summary, findings, conclusions, and recommendations for the study.

CHAPTER 2

REVIEW OF LITERATURE

This chapter reviews the literature pertinent to the research questions. It provides a perspective of the study, investigates prior studies, and provides research results. Both research and non-research information is cited to address the study of the traditional teaching model in the Saxon Mathematics Program in certain school systems, and the difference it made in terms of achievement, and the study of the constructivist teaching model used in the Pre-Algebra Program and the difference it made in terms of achievement.

Mathematics Teaching Models

Purdom and Purdom (1992) described four major mathematics teaching models found in classrooms today. The most prevalent teaching model used was the traditional model whose major goal was intellectual development (Shapiro, 2002). The teacher imparted the subject knowledge by lecturing. The most prominent features were an academic focus, a high degree of teacher direction and control, and high expectations for pupil progress. During instruction, academic activity was emphasized and the use of nonacademic materials – such as games, manipulatives, and puzzles – was deemphasized, as was nonacademically oriented student-teacher interaction. The classroom activities were teacher-driven as the progression of the learning. There was no student-to-student interaction in the classroom. Different needs of students were not addressed. All students were presented the same materials at the same time, with little regard as to the outcome, except for the grade on the report card.

The second mathematics teaching model was the technological approach which has become more prevalent today with the use of the computer in instruction. As with the traditional approach, the teacher's role in the technological approach was active, and the student's role was passive (Shapiro, 2002). The teacher was required to program the instruction into the computer. Students, working alone, were isolated from each other. There again was no student-to-student interaction. The student could, however, work at his/her own pace which made this model approach more individualized than the traditional approach. An example of this style of teaching is the popular Accelerated Math used in many elementary and middle schools, and the "I Can Learn" labs that are used in the high schools to teach algebra. The "I Can Learn" program is a complete education system that manages all of the tedious and repetitive tasks of teaching: homework assignments, lesson presentation, manipulatives, group projects, cooperative learning, peer teaching, authentic and alternative assessments, rubrics and grade evaluations. Each "I Can Learn" course is a complete curriculum that adheres to the National Council of Teachers of Mathematics (NCTM) Algebra I standards. It is based on real-world application problems and incorporates manipulative exercises and a built-in graphic calculator. The "I Can Learn" algebra curriculum was designated as a "Promising Mathematical Program" by the United States Department of Education because of its proven success in educating at-risk students (U. S. Department of Education, 1998). There is little student-to-student interaction and there are a few ways for students to show creativity.

The third mathematics teaching model was the personalized approach which is used less than the other models. This model required the teacher and students to set the goals for instruction; then the students worked along on their projects at their own pace. The student's role was active, taking the initiative for his or her own learning. The teacher's role was one of instructional director, guiding the student toward individual inquiry. This teaching model focused on facilitating learning where the environment was organized to help students attain greater personal integration, effectiveness, and realistic self-appraisal. The teacher's goal was to help the students understand their own needs and values so that they could effectively direct their own educational decisions (Shapiro, 2002). The major criticism of this approach was too little student-to-student involvement. This model of teaching did little to promote group interaction. An example of the personalized teaching model is the traditionalized Montessori schools that have children working independently of each other.

The fourth kind of mathematics teaching model was the interactive model whose framework was based on constructivism. As with the personalized approach, the teacher and the students set the group goals. The students, in smaller groups, together worked in problem solving learning and group projects while generating new and creative ideas. The teacher was active, facilitating group inquiry and checking for student understanding and involvement. The activities of the group emerged with a minimal amount of external structure provided by the teacher. The students and teacher have equal status except for role differences. The atmosphere was one of reason and negotiation. This interactive model had some of the same characteristics as constructivism (Shapiro, 2002). Cooperative learning approaches illustrate this model of teaching. The teaching role is a challenge and requires significant pre-planning because the essence of inquiry is student activity – problems cannot be imposed. At the same time the teacher must facilitate the group process, intervene in the groups to channel their energy into potentially educative activities, and supervise these educative activities so that personal meanings come from the experience (Thelen, 1949). Intervention by the instructor should be minimal unless the group stops the discussion. A criticism of this teaching model was that often the needs of the individual were sacrificed for the good of the group (Purdom & Purdom, 1995).

Further research and nonresearch information is cited to address the two mathematics teaching models used in this study. Table 1 compares selected characteristics of the four teaching models.

Table 1

Comparison of the Four Teaching Models

	TRADITIONAL (Non-Constructivist)	TECHNOLOGICAL	PERSONALIZED	INTERACTIVE (Constructivist)
Major Goal	Intellectual Development	Systems approach to teaching	Maximum development of the individual	Critical Thinking
Student Role	Passive	Passive	Active	Active
Teacher Role	Active	Active	Instructional director	Instructional director
Knowledge	Fixed	Fixed	Open-ended subject of inquiry	Open-ended subject of inquiry
Student-to-Student Interaction	None	None	Open Atmosphere	Open Atmosphere
Student Involvement	None	None	Great	Great
Criticism	Cognitive Only	One method of teaching -- behaviorist based	Individual development	Group needs first
Teacher Expertise	Low	High	Low	High
Examples	Saxon Mathematics	Computer Labs	Montessori	Junior achievement; group projects; cooperative learning

Saxon Teaching Model

The Saxon mathematics model uses the traditional teaching model. Saxon mathematics is a content-based curriculum that explicitly teaches skills and concepts through direct instruction. It is called "the basics" because it consists primarily of arithmetic or computation. It is finding answers to questions such as "30 is what percent of 87?" It is "solving for x" and "memorizing formulas." A list of items important to the basics includes the following:

- Counting accurately to 100 or more
- Mastery of basic facts for all four operations
- Pencil and paper computation skills with whole numbers, decimals, and fractions
- Solving percent problems
- Knowing and using formulas for area and perimeter of basic shapes. (deWalle, 2002).

Klein (2000) noted that it was not possible to teach conceptual understanding of mathematics without supporting the basic skills, and basic skills were weakened by a lack of understanding if not conceptually taught. In another study, Klein (2001) noted that a mathematics program should explicitly teach skills and concepts with appropriately designed practice sets and such programs have the best chance of a success with the largest number of students. Izumi and Coburn (2001) described the Saxon Mathematics Program as a teacher-centered math program that emphasized practice and basic computational skills. Plato (1998) noted that by using Saxon, teachers could learn methods of teaching math concepts that were previously unknown to them. The students could realize that a concept was not simply learned for a test and forgotten. Clopton and

McKeown (1999) concluded that the Saxon program had many high-quality features of presentation including clear statements of the lesson objectives, daily structure, clear and explicit instructional materials, frequent assessments to monitor student progress, and efficient instructional style in the presentation of each new concept. The same study also noted that the consistent structure and clarity of presentation in Saxon math should combine to produce a program that was easily implemented in the classroom.

Saxon's instructional methods are rooted in three basic tenets: incremental development, continuous distributed review, and frequent, cumulative assessment. The efficacy of each of these instructional methods was supported by research before the publication of Saxon's first textbook (Saxon, 2002). Research continues to support the application of these methods of the Saxon pedagogy. What follows are descriptions of each of those methods.

Incremental Development

Incremental development was used to describe how Saxon organized his math lessons. Believing that repetition is a key to mastery, Saxon introduced a concept and kept it reappearing throughout his material. Concepts were practiced four or five times before the next facet of the concept would appear (Saxon, 1987). Concepts were introduced in a spiraling technique throughout the literature. Students learn different algorithms horizontally over time, rather than vertically all at once. This gives students with poor study habits or who have trouble learning in the past more time to think, absorb, and learn (Hart, 1996).

Earlier studies (Ausubel, 1969; Brophy & Evertson, 1976) suggested there might be value in such a teaching method that used small, easily digested chunks. Ausubel

(1969) agreed that ideas were not learned in a single presentation but over time. "Formal education is a slow, incremental process. . . practice is necessary. . . to master most classroom learning" (p.1). Hirsch (1996) later noted that studies such as those by Brophy and Evertson (1976) and Rosenshine and Stevens (1986) regularly stressed the importance of teaching new content in small incremental steps. Hirsch explained the reason for the success of an incremental approach in terms of cognitive psychology:

> The mind can handle only a small number of new things at one time. A new thing has to become integrated with prior knowledge before the mind can give it meaning, store it in memory, and attend to something else. New learnings should not be introduced until feedback from students indicates they have mastered the old learnings quite well (p. 163).

In 1984, Klingele identified incremental development as a point of study, comparing Saxon's incremental approach to a traditional one. The study showed a significant increase of test scores with the group that used the incremental approach, and the researchers credited the success to the fact that the incremental approach was based on principles of sound instructions, such as task analysis, time on task, scheduled practice, and continuous review (Klingele, 1984).

Dempster (1991) reported that the quantity and quality of learning improved with his students when previous material was reviewed regularly. Spaced repetitions, as opposed to mass reviews, held student's interest better and were much more effective. Also in the 1999 *Curriculum Handbook*, authors stated that review was a teaching function that could be done more frequently with textbooks that employ frequent use of spaced review like Saxon's books. More recent studies have found that many students attributed their success in math to Saxon's incremental style (Hansen & Green, 2000) and that an attractive feature of the Saxon program is the development of mathematical concepts using methods that are gradual, systematic, and accessible to students (Klein, 2000).

Continuous Distributed Review

Continuous distributed review (CDR), a second descriptor for Saxon's approach, has often been thought to best describe Saxon's philosophy on daily homework assignments. In CDR, each assignment contains only about 10 percent of its problems from the new topic and the remaining 90 percent from previous concepts already covered during the year. The purpose of this approach is again to automate fundamental skills and focus on them as a necessary precondition for higher order applications in the process (Gagne, 1983). Bloom called automaticity essential for the mastery of any skill whether a routine daily task, such as time on task, or a highly refined talent (Bloom, 1986). As early as 1951, Hovland had decided that CDR was superior to mass practice in both verbal and motor learning for most students. Work on this idea over the next 40 years was summarized by Loree (1970) in *Psychology of Education* in which he stated that the CDR approach had permitted the maintenance of a high level of performance and that individual motivational level could be maintained more easily over short practice sessions. The roots of research on the effects of CDR on math achievement go back even further to the seminal work of Thorndike in the late 1920s. Much of his research published in the *Journal of Experimental Psychology* concluded that CDR is superior to mass practice in areas of acquisition and retention. Thorndike (1940) noted that certain factors that generally interfere with learning decrease over time more rapidly than positive learning tendencies. More recently, Rosenshine and Stephens (1986) related how the review to automaticity processes and higher-level thinking are closely related. They noted in the mid-1980s how extensive practice and frequent review are needed after the material is first learned so that it can be recalled effortlessly and automatically in future work. When prior learning is automatic, this frees space in one's working memory, which can then be used for application and higher-level thinking (Rosenshine & Stephens, 1986).

Studies continued to show that continual practice and review were effective strategies for improving student achievement at all grade levels. Dempster (1991) in his studies suggested that when reviews were incorporated into the learning process, "not only the quantity of what is learned but also the quality" is affected (p. 73). Dempster said that reviews "may shift the learner's attention away from the verbatim details of the material being studied to its deeper conceptual structure" (Dempster, p. 73). Dempster cautioned that it was insufficient to review new material an hour or two after it was introduced. Reviews should occur continually and regularly:

> Reviews that are spread out or distributed over lengthier periods of time [are more effective]. This phenomenon – know as the "spacing effect" – is one of the most robust and dependable phenomena yet documented by psychologists. In fact, two spaced presentations are often about twice as effective as two massed presentations, and this advantage tends to increase as the frequency of review increases. (Dempster, 1991, p. 72).

Mayfield and Chase (2002) noted that research has shown that practicing mixed, incrementally introduced concepts produced greater efficiency in skill acquisition and posttest achievement. True (1987) concluded that continual, systematic review did not limit its positive effects to particular age levels or ability groups. Hansen and Greene (2000) noted that teachers found Saxon's incremental approach to instruction appealing because it allowed students to develop mastery and automaticity through continuous repetition and practice.

Frequent Assessment

Frequent, cumulative assessment is the third descriptor given to Saxon's instructional methods. Dempster (1991) noted that higher levels of achievement occurred when testing was frequent and cumulative rather than infrequent or related only to content covered since the last test. Research further indicated that well-designed classroom testing programs had a positive impact on later student achievement when tests were:

- administered regularly and frequently;
- an integral part of the instructional approach; and
- collected, scored, recorded, and returned to students promptly so that they can correct errors of understanding before these become ingrained. (Dempster, p. 74)

Cotton (2001) also noted that students who were tested frequently and given feedback were found to have positive attitudes toward tests. According to another study, students whose teachers used frequent class tests scored higher than those who used portfolios and projects (Blair, 2000). Izumi & Coburn (2001) found that multiple assessments provided a clear indicator of how well students were doing.

Incremental learning is often used to describe what occurs in a Saxon class. This concept of learning has been referred to as knowing how to use a rule without having to know why the rule works (Skemp, 1979). Other characteristics associated with instrumental learning include specific procedures, drill and practice, and multiple problems. In 1984, Klespis investigated Saxon textbooks and identified many of the above characteristics as being critical to the approach. In other words, with the presence of these kinds of characteristics, the probability of instrumental learning greatly increased. Payne (1983), in her theoretical evaluation of algebra books in the early 1980s, used Skemp's model of instrumental and relational understanding to describe two textbooks. She conjectured that any instrumental-style textbook would benefit not only lower-ability students but also that a relational-style textbook could benefit high-ability students. This information added greater creditability to the Saxon textbooks.

History of Saxon Mathematics

As a result of a self-professed unpleasant teaching experience in class, Saxon concluded that it was the current teaching methods and the textbooks that were the source of the problems that he was experiencing. Using his students as subjects, he developed a unique model of instruction and incorporated it into a textbook (Johnson & Smith, 1987). Since mathematics is considered a textbook-oriented subject, the textbook, itself, determines the instructional methods used in the classroom. To ask Saxon what method he used with his books, one would get a very simple answer-- "common-sense" (Finn, 1988). After writing his first algebra book in 1980, Saxon convinced 20 principals in Oklahoma to participate in an experiment that would test his method of teaching algebra against the more standard texts. He used 1,360 ninth grade algebra students as his test subjects. In the study, students were grouped according to the scores on the California Achievement Test (CAT) in mathematics. The test scores were grouped as low (below the 44th percentile), low-medium (45th-63rd percentile), high-medium (64th-78th percentile), and high (above the 78th percentile). The same teachers taught the control and experimental groups at each school and taught the control group using the mathematics textbook that was normally used. Between February and May, 16 tests were administered to the students. Initial results revealed that those students using Saxon's book outscored the students who were using the standard text by as much as 141% on tests of basic skills. In comparing student scores, Saxon's lowest ability group outscored the control group (Saxon, 1981). Considered at the time a breakthrough in mathematics teaching, the Saxon study drew both criticism and praise. Saxon's critics requested additional research that would conform to strict research techniques. Such a study was conducted in 1982 at the University of Arkansas where students enrolled in a remedial algebra class were divided equally, according to their scores on the American College Testing Program (ACT). No statistically significant difference in the ACT mean scores of the two groups was found. One group was instructed using the Saxon method while the other group was instructed using the standard text. Each group had equal time of instruction, and both were pre-tested. Two forms of assessment were made at the conclusion of the semester. First, the mathematics department faculty developed a departmental final, and second, a Basic Algebra Test was administered that was developed by the Mathematics Association of America. Findings showed a difference of 24 points between the two classes' averages on the departmental final and a 22-point average difference on the Basic Algebra Test in favor of the Saxon group (Klingele, 1984).

In 1984 McBee conducted a study between the Saxon method and a traditional method using the Dolciani algebra textbook in seven public high schools in Oklahoma City, Oklahoma. Students were ability grouped according to their scores on the 1980 California Achievement Test. The same teacher taught the two different classes, one with the Saxon textbook, and the other with Dolciani textbook for the school year. Results of the year's assessment, the Algebra I Comprehensive Exam, showed the Saxon group outperforming the Dolciani group on 11 of the 21 tested topics with no difference in performance on 9 of the topics. The Dolciani group had outperformed the Saxon group on one of the topics. At each ability level, the Saxon students outscored the Dolciani students (McBee, 1984).

Johnson and Smith (1987) conducted a similar study in Oklahoma in 1985-1986 comparing Saxon with the Dolciani algebra textbook. Six teachers taught two classes each, one using the Saxon textbook and the other using the Dolciani textbook, for a total of 276 students. Achievement was assessed using the Comprehensive Assessment Program High School Subject (Algebra I) Tests (CAP). The results showed no statistically significant difference in achievement between the classes. Saxon students scored lower on Definitions and Theory than the Dolciani students. Surveys, though, indicated that the Saxon textbooks were preferred by a majority of the teachers (five of six) and the students (Johnson & Smith, 1987).

At this same time, similar results were being reported in Texas. In 1985, North Dallas High School began using the Saxon program and within three years, the percentage of students passing the Texas State Skills Math Test improved from 10% to 91%. The mathematics enrollment increased by 400-500 percent (Durham, 1995). This lasted but five years until the textbook committee replaced Saxon textbooks with the Scott Foresman mathematics series. As a result, mathematics enrollment dropped, which resulted in a decrease of mathematics teachers from 12 to 8.

In the 1980s, studies showed that the Saxon textbooks and the model of teaching were effective. Why were there more studies? Saxon blamed the National Council of Teachers of Mathematics (NCTM) and its Standards. In 1989 the Standards were the foundation of the push to reform mathematics education and were endorsed by most mathematical groups. Emphasis was placed on student performance shifting from a narrow focus on routine skills to the development of broad-based mathematical knowledge (NCTM, 1989). Teacher performance shifted the authoritarian model of "drill and practice" to student-centered methods featuring active exploration. Saxon and the NCTM differed in several key areas – use of calculators, textbook, and pedagogy-- thus, creating a need for more studies to prove Saxon's textbooks were effective. Table 2 shows a comparison of Saxon and NCTM standards.

Table 2

A Comparison of Saxon and NCTM

	Use of Calculators	Mathematics Curriculum	Standards	Teacher Preparation	Pedagogy
Saxon	No	Basics	Textbooks	Reads a Script	Traditional Model of Teaching
NCTM Standards	Yes	Concepts	National Standards	Practices New Ways of Teaching	Constructivist

One of the most comprehensive studies in the 1990s of the effectiveness of Saxon textbooks was conducted between 1992-1994 by the Oklahoma Department of Education's Testing and Evaluation Department (Nguejen & Elam, 1993). The study observed K-5 students in 56 classrooms using the Saxon program and K-5 students in more than 300 classrooms using non-Saxon programs. Analysis of the 1994 Iowa Test of Basic Skills (ITBS) scores for the Saxon students and a comparison group of the non-Saxon students revealed that the Saxon mathematics group scored higher than the comparison group in all NCE comparisons; however, only one comparison was statistically significant ($p < .05$) (Ngyuen & Elam, 1993). Results of the survey, classroom observations, and discussions with school personnel indicated overwhelmingly positive remarks of the Saxon Mathematics Program from principals and teachers. A study conducted by Sistrunk and Benton (1992) found that when students used Saxon's Mathematics Program for two years, they made significantly greater gains in number concepts, math application, and total battery scores than did students receiving only one year of instruction. Saxon math increased both test scores and self-esteem that made the students more independent in their work habits (Sistrunk & Benton, 1992).

Most of the schools that used Saxon's textbooks were either public schools in non-adoption states or private schools that were exempt from state textbook guidelines. Saxon's Mathematics Program appealed to Christian educators. Because the Saxon texts were not on the official textbook adoption list, school systems in Texas which wanted to use the Saxon books had to apply to the Texas Department of Education for a textbook waiver. In 1991, 25 school districts received waivers from the Texas Board of Education to use Saxon mathematics textbook waivers and found that there had been no textbook waiver requests in the past three years (Texas Board of Education, 1995). State board members then requested information concerning the mathematics results for those 25 school systems. Being compared to similar type schools, the Saxon schools had a higher passing rate on the 1993 Texas Assessment of Academic Skills (TAAS) but showed a 21 percent decrease in their 1994 test scores. Data did not reveal the cause for the decrease; therefore, it could not be determined to what extent the Saxon textbooks impacted the students' results (Texas Board of Education, 1995). By 1993, over 4000 school districts throughout the country were using the Saxon Mathematics Program (Durham, 1995). Success stories at all grade levels were reported throughout the 1990s. For example, after using the Saxon Mathematics Program for three years, students in Huntsville, Tennessee, saw the ACT College Entrance Exam scores increase on the average from 13 to 22 points. Enrollment in upper-level mathematics classes also increased almost 400 percent (Durham, 1995). Similar reports from Window Rock High School located in Northern Arizona, revealed an increase on the ACT from an average of 11.6 points to an average of 18.2 points (Hill, 1993). In Tyrone, Pennsylvania, the entire school district adopted the Saxon program and saw remarkable results at every level from kindergarten through high school. Tyrone's school districts' test scores on the California Achievement Test improved about ten percent which is not very significant, but the percentage of students getting a "B" or better in higher level mathematics courses increased dramatically (Hill, 1993). Another example of positive results occurred during the 1993-1994 school year when students at San Fernando High School in California began using the Saxon Algebra Two book and the Saxon calculus book. Within just one year, the Saxon students at San Fernando High School nearly doubled the performance of those students still using the standard text. As well, after two years, the calculus students using the Saxon approach increased their Calculus Readiness Test Scores on an average from 12 to 20 points (Hart, 1996).

Georgia's Involvement with Saxon

Despite the above successes of Saxon's textbooks and teaching, only a small number of schools in Georgia were using the Saxon books. In 1988 following a spring term pilot of Saxon textbooks, Cartersville Middle School began with the Saxon series for grades six through eight. Prior to the instruction of the Saxon textbooks, the Cartersville School Board reported that eighth graders scored in the 59th percentile on the ITBS. By the spring of 1990, the eighth graders were scoring in the 74th percentile. Scholastic Aptitude Test (SAT) mean scores on the math section increased from 438 to 524. SAT scores were one factor used as a criterion in determining entrance into college (Cartersville City Schools, 1999).

In 1995 Georgia educators requested that Saxon textbooks be included on the state textbook adoption list. The Georgia Board of Education in 1995 did not pay attention to the Georgia's educators' request to include the Saxon text on the state textbook adoption list. Saxon was not listed. Legislators approved a bill that would lessen the board's authority on this selection process. Not to be outdone, the State Board then voted to let the school systems use state funds on any textbooks they wanted. Within a short period of time, local school systems had complete freedom to buy any textbook they wished (White, 1995). Seven of Georgia's school systems exercised that freedom and bought the Saxon mathematics textbooks. Cartersville City Schools have been using Saxon math in all grades and have seen increased test scores since the early nineties. They rank in the top five percent of all 180-school systems in Georgia (Georgia Department of Education, 2002). At the present time, more than 20 school systems are using the Saxon mathematics books.

Summary of the Saxon Studies

Critics have been complaining about the focus on basic skills in the Saxon Mathematics Program since the company published its first textbook in 1980 (Hoff, 2002). Criticism has not stopped the endorsements Saxon has received from influential mathematicians who believe early mathematics education should emphasize basic skills and procedures. An independent research firm found that Saxon now claims about 11 percent of the K-4 grades mathematics textbook market, 8% of the classrooms in grades five to eight, and 3% of the high schools (Hoff, 2002a). Recently, the California Board of Education included Saxon products on the state's list of adopted textbooks. Saxon continues to see a dramatic rise in the market share of textbooks. The studies have shown mixed results. Some (Saxon, 1982) have indicated that Saxon's curriculum is superior, whereas others (Pierce, 1984) have shown no advantages of the Saxon Mathematics Program when compared to Pre-Algebra programs (Johnson & Smith, 1987). The effectiveness of the Saxon Mathematics Program is still not clear.

As part of the Third International Mathematics and Science Study (TIMSS) of the 1999 analyses, researchers videotaped and observed teachers in the classroom to determine whether or not instructional strategies were affecting student achievement. "Choice of methods" affected student achievement (U. S. Department of Education, 2001). As a part of the study, a panel of college math professors evaluated transcripts of the eighth-grade lessons in Japan, Germany, and the U.S. They judged the mathematical contexts of the U.S. lessons to be at a seventh grade level on average and determined that none of the U.S. lessons rated in the top percentile. Most disturbing was the news that the panel considered 89% of the U.S. middle school math lessons low quality. The panel evaluated the Japanese and German math lessons to be of the highest quality. More Japanese teachers than American teachers followed the curriculum and standards that were recommended by the National Council of Teachers of Mathematics. Japanese teachers emphasize deductive reasoning and independent discovery, whereas, the U.S. teachers showed the method and then asked students to duplicate the process. United States eighth graders ranked 28th among the 41 countries who participated. Those countries who scored very high on the assessment were taught mathematics using the discovery methods or the constructivist model; whereas, the low achieving countries mathematics classes were being taught using the traditional method. In contrast to the TIMSS results, the domestic story in mathematics achievement offered some encouraging news. Over the 1990s, results on the National Assessment of Educational Progress (NAEP) in mathematics – the Nation's Report Card – have significantly improved. At every grade level tested and for every group, student performance at the close of the decade was stronger than it was at the beginning. Despite these gains, American students are not progressing far enough (Haycock, 2002). The number of eighth graders at or above proficient is 27%, and 34% of the eighth graders scored below the basic level. These students cannot even solve a basic percent problem. Twice as many young people – 35% – are leaving high school without even meeting the basic level of mathematical knowledge and skills (Haycock, 2002). Past student achievement data verified the ineffectiveness of the traditional method of instruction, but still the method is thought to be sufficient. Because the American students continue to lag behind their world peers in mathematics achievement, mastering mathematics has become a major focus. Many experts say that for effective mathematics instruction to take place, the American mathematics teachers need to emphasize the conceptual understanding of mathematical ideas and procedures and discontinue merely using the traditional method of memorizing (NCTM, 2000).

Pre-Algebra – Constructivist Teaching Model

The constructivist teaching model was used in the comparison schools that taught the Pre-Algebra Program. These classrooms appeared less structured than the traditional classrooms. The physical characteristics of the class were different in several ways. Instead of individual desks, there were tables which were more conducive to group work. There was less reliance on textbooks and worksheets. Math journals were used to promote the language of mathematics, and manipulatives were used to assist in student understanding problem solving. The students were engaged in small group instruction in which they had a major role in planning. The teacher was there to guide the students, to ask questions that might spark student inquiry, and to guide the students to a deeper level of understanding. The learning environment was one in which students were safe to take risks, make mistakes, and thus, enjoy the process of learning. Relationships between the teacher and the students were based on earned respect and trust.

In the pre-algebra classroom a constructivist theory provides a framework for teaching mathematics that encourages problem solving, reasoning, and communication. Research studies have shown that students in a constructivist classroom have had a greater understanding of mathematics and have experienced more success in the mathematics classroom than those in the traditional classrooms (Brewer & Danne, 2002). The constructivist approach differs from the traditional approach in the following five ways:

- Learning results from exploration and discovery.
- Learning is a community activity facilitated by shared inquiry.
- Learning occurs during the constructivist process.
- Learning results from participation in authentic activities.
- Outcomes of constructivist activities are unique and varied. (Alesandrini & Larson, 2002, pp. 118-119).

At the present time, there are four major perspectives within the constructivist movement that recommend different classroom methods. What follows are descriptions of each of those perspectives.

The Piagetian Classroom

The focus of Piaget's theory is the various reconstructions that an individual's thinking undergoes in the development of logical reasoning (Piaget, 1967). These reconstructions result from the learner's manipulation of objects and the recognition of conflict between his perceptions and the data. In this way, the learner gradually foregoes illogical ways of thinking (Piaget, 1970). The importance of the individual's many reorganizations is that they gradually lead to the capability of constructing and testing hypotheses in multifactor situations (Green & Grealer, 2002). Schooling, according to Piaget (1973) should include spontaneous student experimentation, both independent and collaborative. Group situations, in which one's views are challenged, can contribute to the development of objectivity in thinking. The learner is self-aware and self-directed (Green & Grealer, 2002). In the Piagetian classroom the teacher must create and organize classroom experiences that challenge students' thinking, become attuned to the spontaneous mental activity of learners as they address these situations, and provide examples and probing questions that lead students to rethink their hastily developed ideas (Piaget, 1973). The perspectives of Piaget are outcome-oriented in that classroom goals are established.

Vygotsky's Perspective

The focus of Vygotsky's theory was to delineate the outcomes of cognitive development and the processes responsible for these capabilities. Vygotsky identified these complex skills as categorical perception, conceptual thinking, logical memory, and voluntary attention (Vygotsky, 1931-1997). He suggested that conscious awareness and mastery of one's thought processes are only beginning to emerge at school age and the role of classroom instruction is to develop these capabilities. Productive instruction calls this emerging awareness and control to life and leads to the development of higher psychological functions (Vygotsky, 1934-1987). This goal is accomplished through the mastery of subject-matter concepts as part of a system of logical categories and opposites and learning to think with concepts (Vygotsky, 1928-1931-1998b). In the classroom, teacher-student exchange is the primary mechanism for learning in this approach. The process of learning to think in concepts is done by the learner in collaboration with the teacher in instruction (Vygotsky, 1934-1978). This requires the teachers to have an in-depth knowledge of the mathematical concept networks. Teacher modeling is the instructional method used (Vygotsky, 1934-1997).

Social Constructivism

The social constructivist views the classroom as a community charged with the task of developing knowledge (Green & Gredler, 2002). Social constructivism defines learning as socially shared cognition that is co-constructed within a community of participants (Bredo, 1994). The knowledge is inseparable from the activities that produce it, and the learner's role is to participate in a system of practices that are themselves evolving (Cobb & Bowers, 1999). In the classroom the community consists of novices in both the subject matter and in the processes of inquiry. Students participate in small-group and whole-class interactions (Cobb & Bowers, 1999). These forms of co-participation reflect the definition of learning in social constructivism. Learning is not confined to the individual's mind (Marshall, 1996). Instead, learning is viewed as distributed among the participants (Bredo, 1994). Students and teachers each have ownership of certain forms of expertise-no one has it all.

Holistic Constructivists

The holistic constructivist believes that learners must begin with an understanding of the whole rather than its parts (Green & Gredler, 2002). Moving from whole to part is assumed effective because holists believe that students are more motivated to learn narrow skills when they see the larger context into which these skills fit. Student ownership of the learning process and its outcomes is the overarching goal of holistic approaches (Au, Mason, & Scheu, 1995). A basic assumption is that children learn when they are in control of their learning and know that they are in control (Goodman & Goodman, 1992). This control is important to holists because they stress that each learner brings unique personal and social histories, experiences, and interpretations to any new learning situation (Green & Gredler, 2002). Holists stress building on the strengths and interests of students as a way to encourage student control (Goodman & Goodman, 1992). The teachers become the facilitators of learning who create authentic contexts that will stimulate the students to meet their won learning needs. This requires an understanding of student backgrounds, culture, and prior knowledge (Gredler, 2001). The four perspectives of constructivism all shared the belief that students actively construct their own learning, but they also differed in key ways.

History of Constructivism

The constructivist learning theory was accentuated by a movement away from behavioral learning theories (Skinner, 1953; Thorndike, 1913) and toward "a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities" (Wilson, 1996, p. 5). The historical foundations for the constructivist theory of learning are found in John Dewey's (1938) *Education and Experience*. Dewey advocated a paradigm shift from ". . . learning from texts and teachers, [to] learning from experience" (1938, pp. 19-20). Fosnot (1996) indicated that constructivism was a "theory of 'knowing' and a theory of 'coming to know'" (p. 167). He viewed constructivism as a learning theory rather than as a formula that could be implemented as a mere instructional technique.

> Constructivism is a theory of learning, not a description of teaching. No "coverbook teaching style" or pat set of instructional techniques can be abstracted from the theory and proposed as a constructivist approach to teaching. Some general principals of learning derived from constructivism may be helpful to keep in mind, however, as we rethink and reform our educational practices. (p. 29)

Gagnon and Collay (2001) indicated that in the constructivist paradigm, learners construct their own knowledge on the basis of interaction with their environment and that there are assumptions that capture the heart of constructivist learning that forwards that knowledge is:

- physically constructed by learners who are involved in their environment;
- symbolically constructed by learners who are making their own representations of action;
- socially constructed by learners who convey their meaning making to others; and,
- theoretically constructed by learners who try to explain things they do not understand. (Accessed June 17, 2003, at http://www.prainbow.com)

Influenced heavily by Piaget (1973), constructivism is a learner-centered theory of knowledge building, and:

> Constructivists view learning as a result of mental construction. Students learn by fitting new information together with what they already know. People learn best when they actively construct their own understanding.
> (http://hagar.up.ac.za/catts/learner/lindavr/lindapg1.htm)

For the constructivist, learning occurs when beliefs, philosophies, and perception are challenged through social interactions, interactions that can include conversations with others, reflection, and inquiry. Based on experience and interacting with others, new meanings are constructed to form new knowledge. This information or experience allows the learner to reinforce theories of practice, and/or create new practices (Dewey, 1938; Walker & Lambert, 1995). For Glickman (1980), learning occurs when, ". . . knowledge that enables individuals to act with others in ways to improve the conditions of all is of greatest importance" (p. 62).

Legislative Reform

On January 8, 2002, President Bush signed into law the *No Child Left Behind Act of 2001*. The act was the most sweeping education reform of the Elementary and Secondary Act (ESEA) since ESEA was enacted in 1965 (NCTM, 2002). The law redefined the federal role in K-12 education. Its aim is to have all students at proficient levels of reading and mathematics by 2014 (NCTM, 2002). The intent of the NCLB legislation is to close the achievement gaps between students who are of different genders, belong to minority groups, have disabilities, are economically disadvantaged, or have limited English proficiency (NCTM, 2002). To accomplish this, NCLB addressed four principles – accountability for students' academic achievement, local control of federal education dollars, parental involvement, and implementation of scientifically proven programs and teaching methods (NCTM, 2002). Each one of the four principles contained certain criteria that were to be used to judge whether or not states and schools were in compliance with the federal law. Failing to comply, schools and states would risk losing federal money.

The first principle, school accountability, required that states annually test students in reading and mathematics in grades 3-8 and once in high school, beginning no later than the 2005-2006 school year. The law required that states use tests that were aligned with their academic-content standards, either by building assessment specifically designed to reflect those standards or by modifying off-the-shelf tests. Georgia already meets the testing requirement under the federal law (Olson, 2002).

In Georgia, Governor Roy Barnes' A+ *Education Reform of Act of 2000* (O. G. G. A., Section 20-2-281), legislated the development and administration of the Criterion

Referenced-Competency Tests (CRCT) to measure student acquisition of the knowledge and skills set forth in the revised Quality Core Curriculum (QCC). This Georgia law required that the tests be administered to students in grades one through eight in the content areas of reading, English/language arts, and mathematics, and in grades three through eight in science and social studies as well (Georgia Department of Education, 2002). The reading, English/language arts, and mathematics CRCT have been administered annually since the spring of 2000 in grades four, six, and eight. Spring 2002 marked the first operational administration in all grades (one through eight) and in all content areas (reading, English/language arts, mathematics, science, and social studies). The CRCT was designed to measure student acquisition of the knowledge, concepts, and skills set forth in the QCC. Only the content standards outlined in the QCC were assessed. The testing program served two purposes – to provide a diagnosis of individual student and program strengths and weaknesses as related to instruction of the QCC, and to measure the quality of education in the state.

The A+ *Education Reform Act of 2000* also established the Office of Education Accountability (OEA) that was given the responsibility to produce school report cards, another federal requirement of the NCLB law. These school report cards would include a school's academic performance, its dropout percentages, its student attendance, and its school completion rate. In addition, the Georgia act mandated that OEA develop performance measures and indicators for an accountability report card (OEA, 2000). A time line was established with the first accountable school year report to be issued during the fall of 2004.

The NCLB law requires schools systems to raise the achievement levels of students in each of five disaggregations – sex, racial/ethnicity, low socio-economical, disabilities, and limited English speakers – very year. Any deviation from steady improvement in any of the subgroups for two consecutive years would result in a school being called low-performing (Fletcher, 2003). In order to accomplish this, the NCLB law contained a provision for research-based teaching materials. The new federal legislation included the phrase "scientifically based research" repeatedly. The National Research Council (NRC) released a report, *Scientific Research in Education* that provided guiding principles for scientific inquiry and discussed designs for conducting scientific research (National Research Council, 2002). Schools are expected to use research-based practices and materials to meet state standards. Federal funding will go only to programs that are backed by evidence, such as Reading First and Early Learning First (NCTM, 2002).

Federal funding program staff has reported that there are not enough strong mathematics education research proposals being presented as research-based (Hoff, 2002b). Mathematics is not as well defined as reading in that the research on effective mathematics programs is not conclusive. In January of 2003 the Bush administration called attention to the need to search for research-based ways of teaching mathematics by organizing a committee whose task it was to conduct the investigations. This effort has encountered a divide between those mathematics educators who want to emphasize the basic skills and those mathematicians who advocate instruction that builds students' understanding of mathematical concepts. President Bush' mathematics initiative has as one of its goals to find a way for the opposing sides to agree on the basic principles of mathematics education. As Whitehurst said:

> We have to move people from the battle lines. We all want the same thing: for children to get a strong foundation in mathematics. (Hoffb, p. 4)

Summary

Debating over how to teach mathematics is not a new topic. This controversy, to teach basic skills or to teach concepts, began in 1989 when the National Council of Teachers of Mathematics (NCTM) defined what students should know in mathematics when it published its first set of content standards. The standard document emphasized that students should understand the concepts as well as be able to perform the basic operations. Within a couple of years, the National Science Foundation began subsidizing projects that conformed to the NCTM standards. Textbooks were also being influenced by these standards. By the mid 1990s there were some mathematicians who began criticizing the standards and discrediting them. These critics believed that the NCTM standards did not prepare students for higher-level mathematics. In 1997 the California Board of Education adopted standards that emphasized the basic skills, such as computation, and deemphasized the NCTM standards. Within a couple of years, the U.S. Department of Education declared ten mathematics programs “exemplary,” --all reflected the NCTM standards. The opposing side to the NCTM standards, the basics, published an opened letter to the Secretary of Education, Richard Riley, and asked him to withdraw the status bestowed on these programs (Hoff, 2002b). Proponents of the programs that emphasized concepts contended that student achievement would increase if students were taught in this way.

In 2002 the NCTM published revised standards that emphasized both, concepts and basic skills, but was still criticized by the basic proponents that there were not enough changes. The National Reading Council then wrote a report that suggested that the opposing sides in the math wars agree that both basic skills and conceptual understanding be taught; thus, a committee of both, basic skills and concepts, was formed (Hoff, 2002b). Collaborating together, they published a document of mathematical expectations that 8th graders should learn. In 2003 President Bush implemented a project that will evaluate research in mathematics education and determine what programs are affecting student achievement.

The current review of literature concerning the two sides, basics and reform, are mixed and inconclusive; thus, there is a need for increased studies on the two programs to determine which one has the greater effect on student achievement.

CHAPTER 3

METHODOLOGY

The purpose of this section is to describe the research design, procedures, statistics, and other characteristics which formulate the major aspects of the methodology utilized for this project. Following a listing of the null hypotheses derived from the original research questions, a description of the population and sample is given, and the rationale for the particular experimental design selected is discussed. The independent and dependent variables are then identified. Specific information regarding the various instruments used to measure these variables is provided. A chronology detailing the actual procedures used in this study follows.

Research Design

The design of this study was a quasi-experimental design. The sample for this study included the 2000-01 sixth graders at four middle schools. Two of the schools used Saxon mathematics textbooks. In preservice workshops teachers received the information that instruction in the Saxon mathematics classes was to be taught in the same manner everyday-review homework, lecture, and assign homework. Student questions were to be encouraged, but the lecture technique would be the primary way of delivering the lesson. Textbook sequence was to be followed. In contrast, the two middle schools that were using the Pre-algebra Program were instructed to incorporate group work and manipulatives, as well as the more standard lecture and practice components. Curriculum guides were used to indicate what topics were to be taught and in what sequence.

Treatment

The treatment or type of instruction provided to students was based on whether the curriculum was the Saxon Mathematics Program, a traditional basic model, or the Pre-Algebra Program, a constructivist reform model. The academic content was based on the local curriculum objectives and the state mandated Quality Core Curriculum (QCC) objectives.

Saxon Mathematics Program

In the Saxon classrooms, the whole group approach was used so that all of the students in class were on the same lesson at the same time. The textbook was the main instruction that the teachers used. Each lesson presented a small portion of mathematical content that built on students' prior knowledge and understanding. All lessons were written using the same procedure:

- Introduction of an increment
- Examples with complete solutions
- Practice of the new increment
- Cumulative problem set covering all previous increments

Teaching techniques and grading procedures varied, but there were three elements of the program that remained constant:

- Lessons were presented in sequence, and no lessons were skipped.
- No more than ten to fifteen minutes were spent teaching the new increment. Students spent the majority of class time doing mathematics by working on the problems in the problem sets.

- All problems in each practice and problem set was assigned. There were no assignments of just the odd-numbered or even-numbered problems.

In the inservice workshop, teachers were given instructions as to how to conduct their mathematics class. Each day would begin with a 10-15 minute warm-up that would normally consist of those problems that were missed most often on the previous test. Everyone in class was to be involved and receive immediate feedback. Several times the teacher was to interject a small lesson whenever necessary. Then five to ten minutes was to be spent to check and grade homework by students checking answers from an overhead transparency. Prompt feedback was to be always given. The third part of the lesson was the teacher lecture on the new increment for the day. Practice problems were used to illustrate the new increment, and the students were required to do the practice problems as part of the daily assignment. It was not essential for the students to understand the new lesson completely before they left the classroom because there would be future opportunities to explain it in other lessons. For the remainder of the class time, students were to work independently on the new problem set while the teacher answered individual questions and assisted those students who needed extra help. Classroom procedure was the daily ritual. Students would write their notes and practice problems in a notebook.

Assessments occurred daily as well as at test time. The first written assessment was given after every eight lessons, and the rest of the tests were given after four lessons. Each test was cumulative, and thus resembled a final examination. A student who scored below 75-80 percent on a test received remedial attention and was then given another test.

The textbook reviewed everything in every lesson for the entire year. Topics were never dropped but were practiced in every problem set. As the problems became familiar, students looked at the new problem and recognized it by type. This recognition evoked conditioned responses that lead to solutions.

Pre-Algebra Model

The Pre-Algebra curriculum reflected constructivist theories of learning. Teachers received information in their inservice workshops as to how to conduct their mathematics classes. Students were to work in small groups or pairs, actively exploring mathematical ideas. Lessons were to be designed so that students could build upon their substantial informal knowledge by making connections to everyday experiences. To help students' thinking during problem solving and discussions, teachers were to use various manipulatives. Computers and calculators were also to be used.

Teaching through problem-solving placed the focus on the students' attention on ideas and sense making rather than on following the directions of the teacher, and it also provided ongoing assessment data that were used to make instructional decisions. Teachers taught with the goal of developing the "big ideas," the main concepts in a unit. Few skills and ideas got covered this way. These problems came from not only the textbook, but also from mathematics magazine journals, and from the Internet. The teacher had to be the active listener to find out how different children were thinking, what ideas they were using, and how they were approaching the problem. Ample time was always given when individual or teams shared their solutions. Twenty minutes or more was normally the length of time allotted for the class discussion. Often this was when the most effective learning took place. Table 3 summarizes the mathematics lessons in the two mathematics classrooms.

Table 3

Typical Lesson Structures in Pre-Algebra and Saxon Mathematics Classes

Typical Lesson in a Pre-Algebra Classroom	Typical Lesson in a Saxon Classroom
• Teacher poses a problem. • Students struggled with the problem. • Various students present ideas or solutions to the class. • Class discusses the class's solutions. • Students practice similar problems.	• Teacher instructs students in a concept or skill. • Teacher solves example problems with class. • Students practice on their own while the teacher assists individual students.

Null Hypotheses

The following null hypotheses were tested in this study:

Ho1: There are no statistically significant differences in the Total Mathematics Scores on the Iowa Test of Basic Skills (ITBS) for 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/Ethnicity) and the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/Ethnicity; Gender *x* Race/Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

Ho2: There are no statistically significant differences in the Concepts and Estimation Subtest Score on the Iowa Test of Basic Skills (ITBS) for 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/Ethnicity) and the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/Ethnicity; Gender x Race/Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

Ho3: There are no statistically significant differences in the Problems and Data Interpretation Subtest Score on the Iowa Test of Basic Skills (ITBS) for 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/ Ethnicity) and the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/Ethnicity; Gender *x* Race/Ethnicity; Instructional Approach *x* Gender x Race/Ethnicity).

Ho4: There are no statistically significant differences in the Computation Subtest Score on the Iowa Test of Basic Skills (ITBS) for 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-

Algebra Program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/ Ethnicity) and the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/Ethnicity; Gender *x* Race/Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

Population and Sample

The sample for this study consisted of Marietta Middle School and Warner Robins Middle School using Saxon Mathematics Program and Smitha Middle School and Chestnut Log Middle School using the Pre-Algebra Mathematics Program. Each middle school was comprised of sixth, seventh, and eighth grade students. From the total middle school student population, the sample comprised of the sixth grade students in 2000-2001 who were the eighth grade students in 2002-2003. The only criteria used in the selection process were that the student had both the sixth grade CRCT score and the eighth grade ITBS score and participated in the treatment for three years.

In order to attribute observed differences in schools' performance to the implementation of the program rather than to student characteristics, it was necessary to know the demographic characteristics of the schools using the Saxon mathematics program and the pre-algebra mathematics program. The proportion of students eligible for reduced-cost or free lunch was used as a measure of each school's socioeconomic level. Table 4 shows the demographic features of the schools using the Saxon Mathematics Program and the demographic features of the schools using the Pre-Algebra Mathematics Program.

Table 4

Demographic Characteristics of Schools Using the Saxon Mathematics Program and the Pre-Algebra Program

	Saxon Mathematics		Pre-Algebra	
Demographic Variables	Marietta Middle School	Warner Robbins Middle School	Smitha Middle School	Chestnut Log Middle School
Number of Students	484	233	397	279
% F/R Lunch	27	30	28	30
% African-Americans	47	19	35	36
% Caucasian	25	72	45	61
% Hispanic	17	0	11	0
Number of teachers	123	53	102	50
Average Number of Years of Teaching Experience	10	12	9	12
% Master Degrees	50	50	41	46

Variables

The independent variable of this study was mathematics instruction in four middle schools. Two of the schools used the Saxon Mathematics Program and two used the Pre-Algebra Program.

The dependent variables of this study were the student's Total Mathematics Score, Concepts and Estimation Subtest Score, Problems and Data Interpretations Subtest Score, and the Computation Subtest Score on the Iowa Test of Basic Skills reported for the 2002-2003 school year. The covariate of this study was the students' total mathematics score on the Sixth Grade Criterion Referenced Test reported for the 2000-2001 school year.

Instrumentation

The instruments used in this study were the Eighth Grade Iowa Test of Basic Skills (ITBS) and the Sixth Grade Criterion Referenced Competency Test in Mathematics. The Eighth Grade ITBS served as the posttest, and the Sixth Grade CRCT served as the covariate. The scores for the Sixth Grade CRCT were obtained from the 2000-2001 scores for the students currently in the eighth grade. These scores served as the covariate on the Eighth Grade ITBS that were reported in May 2003. Subjects were removed from the study if the scores from the Sixth Grade CRCT were not available. The Iowa Test of Basic Skills is a norm-referenced test given to students in grades three, five, and eight. The test measures a "broad range of skills in various academic areas. . . [and] are primarily useful in helping teachers determine the level of instruction for a student or a group of students' (Georgia Department of Education, 2002, p.1) Students in the four middle schools were administered the Form J Complete Battery ITBS in the early spring of 2003.

Statistical Analysis

The study used a non-equivalent control group design. Since a post measure was not available for the student groups, the analysis of covariance (ANCOVA) was used (Borg, 1981). Four three-way analyses of covariance were used to analyze the data – one for each dependent variable.

Level of Significance

A significance level of .05 was selected for the tests used in the study. The level of significance is the probability of making a Type 1 error when the null hypothesis is rejected (May et al., 1990, p. 214). The researcher "knows that in rejecting the hypothesis, the decision may be incorrect five percent. . . of the time" (Hinkle, Wiersma, & Jurs, 1979, p. 158). A Type 1 error occurs when the researcher rejects a true hypothesis and a Type II error occurs with failure to reject a false hypothesis.

CHAPTER 4

ANALYSIS OF DATA AND FINDINGS

The results of the study are reported in this chapter. A review of the groups along with a description of the treatment is provided. Analyses of the data are presented.

Review of Sample/Population

The sample for this study consisted of Marietta Middle School and Warner Robbins Middle School using the Saxon Mathematics Program and Smitha Middle School and Chestnut Log Middle School using the Pre-Algebra Program. Each middle school was comprised of sixth, seventh, and eight grade students. From the total middle school students' population, the sample comprised of the sixth grade students in 2000-2001 who were the eighth grade students in 2002-2003.

In order to attribute observed differences in schools' performance to the implementation of the program rather than to student characteristics, it was necessary to know the demographic characteristics of the schools using the Saxon Mathematics Program and the Pre-Algebra Program. Table 5 summarizes the number of students in the Saxon Mathematics Program and the Pre-Algebra Program. The decrease of students in the sample can be attributed to the high transient rate.

Table 5

Student Sample

Groups	Number of Students with 6th Grade CRCT Scores	Number of Students with Both 6th Grade CRCT and 8th Grade ITBS Scores (3 years in progress)	Percent of Student Remaining in Study
Saxon Mathematics	717	491	68%
Pre-Algebra	676	517	76%
Total	1393	1008	72%

Variables

Dependent Variable

The dependent variables for this study were the achievement in mathematics as determined by the standard scores on the ITBS – Total Mathematics Score, Concepts and Estimation Subtest Score, Problems and Data Interpretation Subtest Score, and Computation Subtest Score.

Independent Variable

The independent variable for this study was the mathematics instructional model that was used in four middle schools. Marietta Middle School and Warner Robbins Middle School used the Saxon Mathematics Program and Smitha Middle School and Chestnut Log Middle School used a Pre-Algebra Program in the mathematics classroom.

Results

The findings in this section are the results of the statistical analysis of the instructional model. All statistical tests are parametric since the data meet the assumptions of interval type data and are normal distributions. For each subtest area the descriptive statistics table is provided, followed by the inferential statistical analysis.

An analysis of covariance was used to determine the statistical significance of the treatment. The student score on the sixth grade Criterion Reference Competence Test (CRCT) served as the covariate for these analyses and student scores in the Total Mathematics and the three subtests of the eighth grade Iowa Test of Basic Skills (ITBS) were the dependent variables.

Hypothesis One

Ho1: There are no statistically significant differences in the Total Mathematics Score on the Iowa Test of Basic Skills (ITBS) for the 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics score for the 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the Pre-Algebra Program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/Ethnicity) and the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

The mean for the Saxon group was 257.02 and the mean for the Pre-Algebra group was 252.27 (see Table 6). There was no significant statistical difference in the Mathematics Total scores for instructional curriculum, Saxon Mathematics or Pre-Algebra, was taught [$F(1, 994) = .622$] (see Table 7). Type of curriculum did not contribute to the variation in test scores. There was, however, a significant statistical difference in Mathematics Total scores due to gender [$F(1,994) = 9.567$, $p < .05$] (see

Table 6

Description of Sample Sizes, Ranges, Means, and Standard Deviations for CRCT6 Mathematics Total (Covariate), Eighth Grade Mathematics Total (ITBS)

		Saxon		Pre-Algebra	
		Female	Male	Female	Male
Non-White	N	112	141	143	133
	Range	134.00	160.00	136.00	156.00
	Mean	238.90	245.06	247.67	237.00
	SD	30.27	36.84	30.56	34.37
White	N	125	113	135	106
	Range	128.00	156.00	154.00	162.00
	Mean	273.74	271.12	260.82	266.74
	SD	26.13	36.88	32.09	35.92

Table 7

Summary of Analysis of Covariance for Eighth Grade Mathematics Total (ITBS) Using Sixth Grade CRCT as Covariate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Corrected Model	917447.513	8	114680.939	322.954	.000
Intercept	9727.487	1	9727.478	27.394	.000
CRCTMT (Covariate)	732829.271	1	732829.271	2063.755	.000
Instruction	220.947	1	220.947	.622	.430
Gender	3397.204	1	3397.204	9.567	.002
Ethnicity	9422.847	1	9422.847	26.536	.000
Instruction x Gender	1386.669	1	1386.699	3.905	.048
Instruction x Race	390.857	1	390.857	1.101	.294
Gender and Race	27.963	1	27.963	.079	.779
Instruction x Gender x Race	2092.735	1	2092.735	5.893	.015
Error	352969.403	994	355.100		
Total	66273922.00	1003			
Corrected Total	1270416.915	1002			

Post Hoc Comparison of Means

	Pre-Algebra	Saxon
Nonwhite Male Groups	250.929	255.894*
Nonwhite Female Groups	252.158*	246.568

*statistically significant different, $p < .05$

Table 7). The female mean was the highest with a score of 255.56, and the male mean was 253.56. There was also a significant statistical difference in the Mathematics Total score due to race/ethnicity [$F(1, 994) = 26.536$, $p < .05$] (see Table 7). There was a difference in the mean scores of 25.47 points. The white students with a mean of 267.93 were higher than the non-white students with a mean of 242.46.

There was a significant interaction between the instructional approach x gender [$F(1, 994) = 3.905$, $p < .05$] (see Table 7). The Saxon Mathematics Program worked best for the males. The mean for the Saxon males was 258.09, and the mean for the Pre-Algebra males was 251.87. The mean for the females was higher using the Saxon Mathematics Program than the Pre-Algebra Program. The mean for the Saxon females was 256.32, and the mean for the Pre-Algebra females was 254.25. There was no statistical significant interaction between the instructional approach x race/ethnicity [$F(1, 994) = 1.101$, $p = .294$] or between gender x race/ethnicity [$F(1, 994) = .079$, $p = .779$]. There was a statistical interaction between instructional approach x gender x race/ethnicity [$F (1, 994) = 5.893$, $p < .05$] (see Table 7). The non-white males scored higher with the Saxon Mathematics Program (mean = 245.06) than with the Pre-Algebra Program (mean = 237.00); whereas, the non-white females scored better when using the Pre-Algebra Program (mean = 247.67) than the Saxon (mean = 238.90). The white female scored higher using the Saxon Mathematics (mean = 273.74) than the Pre-Algebra Program (mean = 260.82), and the white male scored the highest using the Saxon Mathematics mean = 271.12) than the Pre-Algebra Program (mean = 266.74).

Post hoc comparison tests revealed that two sets of the race/ethnicity-sex group means were statistically different from each other. The nonwhite male group using Saxon

Mathematics score statistically significantly higher than the nonwhite male group using Pre-Algebra: the nonwhite female group using Pre-Algebra scored statistically significantly higher than the nonwhite female group using Saxon Mathematics. There were no statistical differences for the white male groups and the white female groups which indicated that both mathematics programs, Saxon or the Pre-Algebra, benefited these groups equally.

Hypothesis Two

Ho2: There are no statistically significant differences in the Concepts and Estimation score on the Iowa Test of Basic Skills (ITBS) for the 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the pre-algebra mathematics program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/Ethnicity) and the interaction (Instructional Approach *x* Gender; Instructional Approach x Race/ Ethnicity; Gender x Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

The mean for the Pre-Algebra Program was 251.09 (see Table 8). There was a significant difference in Concepts and Estimation scores due to the instructional approach used [$F(1, 944) = 17.884$, $p < .05$] (see Table 9). Scores were the highest for the students using the Saxon Mathematics Program (mean = 259.54). There was also a significant difference due to gender [$F(1, 994) = 11.423$, $p < .05$] (see Table 9). Females had a mean of 255.68, and the males had a mean of 254.69 (see Table 8). Significant differences were

Table 8

Description of Sample Sizes, Ranges, Means, and Standard Deviations for CRCT6 Mathematics Total (Covariate) Concepts and Estimation

		Saxon		Pre-Algebra	
		Female	Male	Female	Male
Non-White	N	112	141	143	133
	Range	134.00	161.00	142.00	157.00
	Mean	243.05	248.67	247.90	239.00
	SD	30.42	36.11	29.35	33.49
White	N	125	113	135	106
	Range	115.00	156.00	151.00	156.00
	Mean	273.64	273.61	257.75	262.15
	SD	23.15	32.93	31.60	34.61

Table 9

Summary of Analysis of Covariance for Eighth Grade Concepts (ITBS) Using Sixth Grade CRCT as Covariate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Corrected Model	799730.817	8	99966.352	284.031	.000
Intercept	2152.766	1	2152.766	6.117	.014
CRCTMT (Covariate)	648535.308	1	648535.308	1842.660	.000
Instruction	6294.303	1	6294.303	17.884	.000
Gender	4020.497	1	4020.497	11.423	.001
Race	3348.488	1	3348.488	9.514	.002
Instruct x Gender	1963.685	1	1963.685	5.579	.018
Instruct x Race	1622.259	1	1622.259	4.609	.032
Gender and Race	11.975	1	11.975	.034	.854
Instruct x Gender x Race	575.177	1	575.177	1.634	.201
Error	349844.271	994	351.956		
Total	66469138.00	1003			
Corrected Total	1149575.00	1002			

Post Hoc Comparison of Means

	Pre-Algebra	Saxon
Nonwhite Male Groups	252.033	258.859*
White Male Groups	254.678	263.578*
White Female Groups	252.148	258.471*

*statistically significantly different, $p < .05$

also evident in race/ethnicity [$F(1, 994) = 9.514$, $p < .05$] (see Table 9). The white students had the higher mean of 266.61, and the non-white students had a mean of 244.84 with a difference of 21.77 (see Table 8).

There was a significant interaction between instructional approach x gender [$F(1, 994) = 5.579$, $p < .05$]. Statistics show that the Saxon females and males scored higher than the Pre-Algebra females and males. The average mean for the Saxon males was 261.14, and the Pre-Algebra males were 250.26. The average mean for the Saxon females were 258.35 and the average mean for the Pre-Algebra female was 252.83 (see Table 8). There was also a significant interaction between instructional approach x race/ethnicity [$F(1, 994) = 4.609$, $p < .05$] (see Table 9). White and non-white students benefited more when using the Saxon Mathematics Program than the Pre-Algebra Program. The mean for the Saxon Mathematics white students was 273.63, and the mean for the Pre-Algebra white students was 259.95. The mean for the Saxon Mathematics non-white students was 245.86, and the mean for the Pre-Algebra non-white students was 243.45. There was no significant interaction in the Concepts subtest due to gender x race/ethnicity [$F(1,994) = .034$, $p = .854$] (see Table 9). The interaction between instructional approach x gender x race/ethnicity was also not significant [$F(1,994) = 1.634$, $p = .201$] (see Table 9).

Post hoc comparison tests revealed that three sets of the race/ethnicity-sex group means were statistically different from each other. The nonwhite male group using Saxon Mathematics scored statistically significantly higher than the nonwhite male group using the Pre-Algebra Program: the white male group using Saxon Mathematics scored statistically significantly higher than the white male group using the Pre-Algebra Program: and the white female group using the Saxon Mathematics Program score statistically significantly higher than the white female group using Pre-Algebra. There were no statistically significantly differences for the nonwhite female groups which indicated that both mathematics program, Saxon Mathematics or Pre-Algebra, benefited these groups equally.

Hypothesis Three

Ho3: There are no statistically significant differences in the Problems and Data Interpretation score on the Iowa Test of Basic Skills (ITBS) for the 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the pre-algebra mathematics program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/Ethnicity) and the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/Ethnicity; Gender and Race/Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

The mean for the Saxon Mathematics was 254.39, and the mean for the Pre-Algebra Program was 253.86 (see Table 10). Students using the Saxon Mathematics benefited by .52 more than students using the Pre-Algebra Program. There was a significant difference in the subtest of Problems and Data Interpretation score for the instructional approach [$F(1, 997) = 3.872$, $p < .05$] (see Table 11). The p value of .49 indicated that the difference would be small when comparing the two means. There was a significant difference in the subtest score due to gender [$F(1, 997) = 5.085$, $p < .05$] (see Table 11). The females with a mean of 255.27 scored higher than the males with a mean

Table 10

Description of Sample Sizes, Ranges, Means, and Standard Deviations for CRCT6 Mathematics Total (Covariate), Eighth Grade Problems and Data Interpretation (ITBS)

		Saxon		Pre-Algebra	
		Female	Male	Female	Male
Non-White	N	112	141	143	133
	Range	152.00	185.00	153.00	185.00
	Mean	234.58	241.55	247.34	235.12
	SD	34.24	41.15	35.67	38.30
White	N	125	113	135	106
	Range	162.00	156.00	173.00	167.00
	Mean	273.89	268.63	263.78	271.24
	SD	31.81	43.18	35.24	39.96

Table 11

Summary of Analysis of Covariance for Eighth Grade Problems and Data Interpretation (ITBS) Using Sixth Grade CRCT as Covariate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Corrected Model	1056564.390	8	132070.549	224.605	.000
Intercept	22532.365	1	22534.365	38.320	.000
CRCTMT (Covariate)	821204.775	1	821204.775	1396.578	.000
Instruction	2276.843	1	2276.843	3.872	.049
Gender	2990.141	1	2990.141	5.085	.024
Race	18590.996	1	18590.996	31.617	.000
Instruct x Gender	951.745	1	951.745	1.619	.204
Instruct x Race	.453	1	.453	.001	.978
Gender and Race	74.381	1	74.381	.126	.722
Instruct x Gender x Race	4730.516	1	4730.516	8.045	.005
Error	586247.953	997	588.012		
Total	66476331.00	1006			
Corrected Total	1642812.343	1006			

Post Hoc Comparison of Means

	Pre-Algebra	Saxon
Nonwhite Female Groups	252.033*	242.718
White Male Groups	262.779*	257.292

*statistically significantly different, $p < .05$

of 252.41. Ethnicity/race showed as a significant difference in the subtest [$F(1, 997) = 31.617$, $p < .05$] (see Table 11). The white students' mean was 269.21, and the non-white students' mean was 250.02. The white students scored higher than the non-white students.

There was no significant interaction in the subtest scores of Problems and Data Interpretation due to the instructional approach x gender [$F(1, 997) = 1.619$, $p = .204$] or the instructional approach x race/ethnicity [$F(1, 997) = 1.618$, $p = .978$] (see Table 11). There was also no significant interaction between gender x race/ethnicity [$F(1, 997) = 126$, $p = .722$] (see Table 11). There was a significant interaction between the instructional approach x gender x race/ethnicity [$F(1, 997) = 8.045$, $p < .05$] (see Table 11).Post Hoc comparison tests revealed that two sets of the race/ethnicity-sex group means were statistically different from each other. The nonwhite female group using Pre-Algebra scored statistically significantly higher than the nonwhite female group using the Saxon Mathematics: the white male group using the Pre-Algebra Program score statistically significantly higher than the white male group using the Saxon Mathematics Program. There was no statistical significance difference for the nonwhite male groups and the white female groups which indicated that both mathematical programs, Saxon or the Pre-Algebra, benefited these groups equally.

Hypothesis Four

Ho4: There are no statistically significant differences in the Computation score on the Iowa Test of Basic Skills (ITBS) for the 2002-2003 (as adjusted by sixth grade scores in the Georgia CRCT Total Mathematics scores for 2000-2001) for eighth grade students being instructed using the Saxon Mathematics Program in two middle schools for three years as compared to eighth grade students being instructed with the pre-algebra mathematics program in two demographically similar middle schools for the same time period for the main effects (Instructional Approach, Gender, Race/Ethnicity) an the interactions (Instructional Approach *x* Gender; Instructional Approach *x* Race/ Ethnicity; Gender x Race/ Ethnicity; Instructional Approach *x* Gender *x* Race/Ethnicity).

The Saxon Mathematics Program scored the highest with a mean of 270.31 (see Table 12). There was a significant difference in Computation scores for the instructional approach that was used [$F(1, 997) = 63.457$, $p < .05$] (see Table 13). The Pre-Algebra students had a mean of 254.09. There was also a significant difference due to gender [$F(1, 997) = 25.135$, $p < .05$] (see Table 13). The females' mean was 267.65, and the males' mean was 256.11. Race/ethnicity also had a significant difference [$F(1, 997) = 6.577$, $p < .05$] (see Table 13). The white students with a mean of 267.37 were higher than the non-white students with a mean of 257.15.

There was no significant interaction between instructional approach x gender [$F(1, 997) = .749$, $p = .387$] ; instructional approach x race/ethnicity [$F(1, 997) = 2.826$, $p = .093$]; and between gender x race/ethnicity [$F(1, 997) = .16$, $p = .689$] (see Table 13). There was a significant interaction between instructional approach x gender x race/ethnicity [$F(1, 997) = 5.044$, $p < .05$] (see Table 13).

Post Hoc comparison tests revealed that three sets of the race/ethnicity-sex group means were statistically different. The nonwhite male group using Saxon Mathematics scored statistically significantly higher than the nonwhite male group using Pre-Algebra: the nonwhite female group using the Saxon Mathematics scored statistically significantly higher than the nonwhite female group using the Pre-Algebra Program: and the white

Table 12

Description of Sample Sizes, Ranges, Means, and Standard Deviations for CRCT6 Mathematics Total (Covariate), Eighth Grade Computation (ITBS)

		Saxon		Pre-Algebra	
		Female	Male	Female	Male
Non-White	N	112	141	143	133
	Range	153.00	160.00	168.00	168.00
	Mean	269.97	261.95	257.89	240.47
	SD	32.95	36.64	34.68	35.35
White	N	125	113	135	106
	Range	131.00	153.00	153.00	138.00
	Mean	284.49	265.52	260.53	257.95
	SD	26.54	35.98	33.74	35.20

Table 13

Summary of Analysis of Covariance for Eighth Grade Computation (ITBS) Using Sixth Grade CRCT as Covariate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Corrected Model	535967.321	8	66995.915	88.034	.000
Intercept	21515.539	1	21515.539	28.272	.000
CRCTMT (Covariate)	398598.557	1	398598.557	523.766	.000
Instruction	48292.561	1	48292.561	63.457	.000
Gender	19128.018	1	19128.018	25.135	.000
Race	5005.078	1	5005.078	6.577	.010
Instruct x Gender	569.638	1	569.638	.749	.387
Instruct x Race	2150.279	1	2150.279	2.826	.093
Gender and Race	122.340	1	122.340	.161	.689
Instruct x Gender x Race	3838.509	1	3838.509	5.044	.025
Error	758741.654	997	761.025		
Total	70347963.00	1006			
Corrected Total	1294706.975	1005			

Post Hoc Comparison of Means

	Pre-Algebra	Saxon
Nonwhite Male Groups	250.645	269.973*
Nonwhite Female Groups	261.160	275.643*
White Female Groups	256.107	272.570*

*statistically significantly different, $p < .05$

female group scored statistically significantly higher using the Saxon Mathematics Program than the white female group using the Pre-Algebra Program. There was no statistical difference for the white male groups which indicated that both mathematical programs, Saxon or Pre-Algebra, benefited these groups equally.

Summary of Student Data

Summaries of the research findings are recorded in Table 14 and Table 15. For main effects, eleven of the twelve were statistically significant at or beyond the .05 level. For Concepts and Estimation, instructional approach [F(1,994) = 17.884], gender [F(1,994 = 11.423], and ethnicity [F(1,994) = 9.514] were statistically significant. For Problems and Data Interpretation, instructional approach [F(1,997) = 3.872], gender [F(1,997) = 5.085], and ethnicity [F(1,997) = 31.617] were statistically significant. For Computation, instructional approach [F(1,997) = 63.457], gender [F(1,997) = 25.135], and ethnicity [F(1,997) = 6.557] were statistically significant. For Total Mathematics, gender [F(1,994) = 9.567] and ethnicity [F(1,994) = 25.536] were statistically significant.

Regarding the first order interactions, Concepts had a statistical significance with instructional approach *x* gender [F(1,994) = 5.579] and instructional approach *x* race/ethnicity [F(1,994) = 4.609]. Total Mathematics had a statistical significance with instructional approach *x* gender [F(1,994) = 3.905].

The second order interactions, instructional approach *x* gender *x* race/ ethnicity was statistically significant at the .05 level in Problems and Data Interpretation [F(1,997) = 8.045], Computation [F(1,997) = 5.044], and Total Mathematics [F(1,994) = 5.893]. The other tests for main effects and interactions were not significant beyond the .05 level of significance.

Table 14

Summary Table of Findings

	Dependent Variables			
	Total	Concepts and Estimation	Problems and Data Interpretation	Computation
Instructional Approach	=	Saxon>PreAlg	Saxon.>PreAlg	Saxon>PreAlg
Gender	Female>Male	Female>Male	Female>Male	Female>Male
Ethnicity	White>Non	White>Non	White>Non	White>Non
Instructional Approach *x* Gender	SaxonM>PreM PreF>SaxonF	SaxonM>PreM SaxonF>PreF	=	=
Instructional Approach *x* Race	=	SaxonWhite>PreWhite SaxonNon.>PreNon	=	=
Gender *x* Ethnicity	=	=	=	=
Instructional Approach *x* Gender *x* Ethnicity	Saxon NonWhite Males>Saxon Non-White Females PreAlg NonWhite Females > Saxon Non-White Male Saxon White Female > Saxon White Male PreAlg White Male > PreAlg White Female	=	Saxon White Female>Saxon White Male PreAlg White Male>PreAlg White Female Saxon NonWhite Male>Saxon NonWhite Female PreAlgebra NonWhite Female>PreAlg NonWhite Male	Saxon NonWhite Females>PreAlg NonWhite Females Saxon NonWhite Males>PreAlg NonWhite Males Saxon White Females>PreAlg White Females Saxon White Males>PreAlg White Males

Saxon=Saxon
PreAlg=Pre-Algebra
Non=Non-white
M=Male
F=Female

Table 15

Summary Table of Findings in the Two Mathematical Programs

ITBS	Saxon Mathematics Statistically Greater	Pre-Algebra Statistically Greater	Equal Benefit
Mathematics Total	Nonwhite Male	Nonwhite Female	White Male White Female
Concepts and Estimation	Nonwhite Male White Female White Male		Nonwhite Female
Problems and Data Analysis		Nonwhite Female White Male	Nonwhite Male White Female
Computation	Nonwhite Male Nonwhite Female White Female		White Male

In interpreting the results, emphasis was placed on examining the interaction terms to provide for the highest level of understanding of the impact of the two approaches on the subgroups of students studied. Post hoc comparison tests revealed which groups scored statistically significantly different using the two mathematics program. The nonwhite male group using the Saxon Mathematics Program scored statistically significantly higher on the ITBS Mathematics Total, Concepts and Estimation, and Computation. The two mathematical programs did not have statistically significantly different impacts on scores on the ITBS' Problems and Data Interpretation for the nonwhite male group. The white female group using the Saxon Mathematics Program scored statistically significantly higher on the ITBS' Concepts and Estimation and Computation. The two mathematical programs did not have statistically significant different impacts on scores on the ITBS' Mathematics Total and Problems and Data Interpretation for the white female group. The nonwhite female group using the Pre-Algebra Program scored statistically significantly higher on the ITBS" Mathematics Total and Problems and Data Analysis. The nonwhite female group using the Saxon Mathematics scored statistically significantly higher on the ITBS' Computation. The two mathematical programs did not have statistically significance different impacts on scores on the ITBS Concepts and Estimation for the nonwhite female group. The white male group using Saxon Mathematics scored statistically significantly higher on the ITBS' Concepts and Estimation and scored statistically significantly higher on the ITBS' Problems and Data Analysis using the Pre-Algebra Program. The two mathematical programs did not have statistically significant different impacts on scores on the ITBS' Mathematics Total and Computation for the white male group.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Chapter 5 contains the summary of the study. Conclusions are provided followed by recommendation for further study.

Summary

The purpose of this study was to determine the effectiveness of a Saxon Mathematics Program and a Pre-Algebra Program after three years on the achievement of eighth grade students. Four middle schools were used in this study: two schools with a Saxon Mathematics Program and two middle schools with a Pre-Algebra Program. The dependent variables used to measure student achievement were the eighth grade scores on the following subtests of the Iowa Test of Basic Skills (ITBS): Mathematics Total, Concepts and Estimation, Problems and Data Interpretation, and Computation. The sixth grade scores of the Criterion Reference Competency Test (CRCT) served as the covariate. This study used as the independent variable-mathematics instruction.

Marietta Middle School in the Marietta City School System and Warner Robbins Middle School in Houston County used the Saxon Program, and Smitha Middle School in Cobb County and Chestnut Log Middle School in Douglas County used the Pre-Algebra Program. Each middle school was comprised of sixth, seventh, and eighth grade students. From the total middle school population, the sample comprised of the sixth grade students in 2000-2001 who are the eighth grade students in 2002-2003. According to the Georgia Department of Education (2000), the student enrollment of sixth graders at

Marietta Middle School for the 2000-2001 school year was 484. The school racial composition was 47% Black students, 25% White students, and 17% Hispanic. The percentage of students eligible for the federal program of free/reduced lunches was 27%. The average number of years of teaching experience for the certified staff was 10 years, and the percentage of staff with a master's degree or higher was 50%.

Warner Robbins Middle School also used the Saxon Mathematics Program. The 2000-2001 six grade population was 233 students with a school racial composition of 19% Black, 72% White, and 0% Hispanic. Thirty percent of its students were eligible for the federal program of free/reduced lunches. The school staff considered of fifty-three teachers whose average teaching experience was twelve year. Over 50% of the teachers held master's degrees or higher.

Smitha Middle School was one of the two schools that used a Pre-Algebra Program. It is located in Marietta, Georgia, in Cobb County with a 2000-2001 six grade enrollment of 397 students. The racial composition was 35% Black, 45% White, and 11% Hispanic, and 28% of the students were eligible for the federal program of free/reduced lunch. The school staff consisted of 102 teachers whose average number of years teaching was nine years. Over 40% of the staff held master's degrees or higher. Chestnut Log Middle School in Douglas County also used the Pre-Algebra Program. The 2000-2001 sixth grade population was 279 and 30% of them were eligible for the federal program of free/reduced lunch. The racial composition was 36% Black, 61% White, and 0% Hispanic. There were 50 teachers whose average years of teaching were 12 years. Over 40% of the staff had a master's degree or higher.

Information was gathered on the four middle schools for the 2000-2001 and 2002-2003 school years. Data on matched students for grades six and eight were compared between the two years in achievement on the standard scores of the ITBS-Mathematics Total, Concepts and Estimation, Problems and Data Interpretation, and Computation subtests. The sixth grade CRCT was used as the covariate.

Discussion

The study was a comparison of students using the Saxon Mathematics Program and students using the Pre-Algebra Program. Each of the Mathematics subtests of the ITBS was studied for the main effects and interactions, in the variables of instructional approach, gender, and race/ethnicity. Four three-way analyses of covariance were used to analyze the data and determine statistical significance at the $p < .05$ alpha level. In the study, statistically significant gains for instructional approach were found in three of the subtests. Saxon scored higher on two of them – Concepts and Estimation and Computation. One of the subtests, Problems and Data Interpretation, had statistically significant gains in favor of the Pre-Algebra Program. Statistically significant gains for gender were found in all four subtests. The females scored higher than the males – Total Mathematics, Concepts and Estimation, Problems and Data Interpretation, and Computation. Statistically significant gains for race/ ethnicity were also found in all four subtests. The white students scored higher than the non-whites on the Total Mathematics, Concepts and Estimation, Problems and Data Interpretation, and Computation...

The interaction, instructional approach *x* gender, had statistically significance on two of the subtests – Mathematics Total and Concepts and Estimation. The Saxon males scored higher than the Pre-Algebra males, and the Pre-Algebra females scored higher than the Saxon females on the Mathematics Total. Saxon males and females scored higher than the Pre-Algebra males and females on the Concepts and Estimation Subtest. The interaction, instructional approach *x* race/ethnicity, was statistically significant on one subtest – Concepts and Estimation. Saxon white and non-white students both scored higher than the Pre-Algebra white and non-white on this subtest. The interaction, gender *x* race/ethnicity, showed no statistically significance in any of the four subtests.

The three-way interaction, instructional approach *x* gender *x* race/ethnicity, had statistically significant gains on three of the subtests – Mathematics Total, Problems and Data Interpretation, and Computation. Post hoc comparisons showed that on the Mathematics Total the nonwhite male scored higher using the Saxon Mathematics, and the nonwhite female group scored higher using the Pre-Algebra Program, and either program would benefit the white male group and white female group. On the Problems and Data Interpretation Subtest, the nonwhite male group, the white female group and the white male group scored higher using the Saxon Mathematics Program, and the nonwhite female group would benefit from either program. On the Computation Subtest, the nonwhite male group, the nonwhite female group, and the white female group scores were higher using the Saxon Mathematics. Either program would benefit the white male group.

Conclusions

The results of this study indicate that there is a definite need for differentiated instruction in the mathematics classroom. The nonwhite female group benefited the most from the Pre-Algebra Program which indicates that this group learns more effectively when actively involved in the lesson. This group needs the interaction of group work and communication. It is different for the nonwhite male. Nonwhite males seem to learn most effectively with structure and less student interaction. By varying the ways in which students work whether alone or in a group, in auditory or visual modes, will maximize the learning capacity of each student.

The Saxon Mathematics Program does teach mathematical concepts effectively with three of the groups of the students. This result does not agree with other research in the field. The study does, however, support the research about gender differences being the greatest in those courses that are conducted with the time-honored chalk and talk format. It also supports the research that students master computation skills using Saxon Mathematics. Each of the two mathematical programs, Saxon and the Pre-Algebra, has strengths for different race/ethnicity sex-groups. One program should be supplemented with the other program in the classroom to ensure maximum mathematical growth for all students.

Recommendations

Based on the observations and findings of this study, the following recommendations are suggested for consideration:

1. This study involved data collection without involving classroom visits to determine teacher quality. A study should be conducted to see whether or not teacher quality effects student achievement.
2. This study should be continued, and the Eighth Grade CRCT should be used to access the mathematical content that is actually being taught in the schools.
3. A study should be conducted investigating the effects of students reading level on student achievement in mathematics.

4. A study should be conducted investigating mathematical programs for the exceptional students.

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Teaching math in a mixed-ability classroom should take into account different learning abilities. Teaching in today's mixed-ability classroom can be a challenge. These days, it's not uncommon to find a wide range of abilities in the one classroomâ€"from students struggling to grasp new concepts, to those who are way ahead of their peers from day one.Â Focus your feedback on the task itself (rather than the student) and make sure they have a clear understanding of what they did well and how they can improve next time. In Carol Dweck's research around what's known as the 'growth mindset', she writes: â€œThe growth mindset was intended to help close achievement gaps, not hide them.