

AMSTI MATHEMATICS IN GRADES 4 AND 5: STUDENT
ACHIEVEMENT AND TEACHER PERCEPTIONS

by

JUDY BENNEFIELD BRIGHT

A DISSERTATION

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ABSTRACT

Concerns with the deficiencies of student achievement in mathematics have prompted reform efforts. This study investigated one reform effort called the Alabama Math, Science, and Technology Initiative (AMSTI). Quantitative data were collected from the results of *Stanford Achievement Test Tenth Edition (SAT 10)* and the *Alabama Reading and Mathematics Test (ARMT)*. Qualitative data were collected from the participating teachers.

Fourth- and fifth-grade students from four, rural, elementary schools were involved in this study. Two schools were classified as AMSTI schools where the teachers had participated in at least one two-week session of professional development. Two schools were identified as non-AMSTI schools. The participating teachers from the non-AMSTI schools had not received training.

Quantitative data were collected from the *SAT 10* and *ARMT* for school years 2008-2009 and 2009-2010. The students' scores were analyzed using an independent samples *t* test. Results of the study demonstrated that there was no statistically significant difference in the *SAT 10* and *ARMT* mean scores of the students in AMSTI schools and the mean score of the students in the non-AMSTI schools.

Qualitative data involved individual teacher interviews of AMSTI teachers and non-AMSTI teachers based on their perceptions of AMSTI. The interviews were transcribed and studied to determine emerging themes. The dominate themes were AMSTI's impact on teachers, its impact on students, and time required to implement it. The AMSTI teachers had varied opinions of the impact AMSTI had on them and their students; however, all the teachers agreed

that AMSTI was challenging to implement. They liked many of the AMSTI strategies, but found it difficult and time consuming to implement AMSTI and meet the mandated requirements that were already in place in the classroom. Additionally, the teachers commented that AMSTI had positively impacted their students with the activities and games. Students were also impacted by the hands-on work with manipulatives and the group work associated with most AMSTI strategies.

The non-AMSTI teachers had perceptions primarily based on what they had heard and interpreted from conversations with other teachers. Like the AMSTI teachers, these teachers also saw pending problems with incorporating AMSTI into the required curriculum.

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and then a man's mind is stretched by a new idea or sensation, and never shrinks back to its former dimensions." How fortunate I am to have known you!

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CHAPTER 1

INTRODUCTION

Reform in mathematics education has been prompted partly in response to the acknowledged failure of traditional methods of teaching mathematics (Battista, 1999). For decades, Americans have been aware that their students rank behind in mathematical tests when compared to students of other countries (Romberg, 1997).

Concerns with the deficiencies of student achievement in mathematics were made public when two critical advisory national reports were published. In 1983, *A Nation at Risk*, published by the National Commission on Excellence in Education, and *Educating Americans for the Twenty-First Century* published in the same year by the National Science Board Commission on Education, made the claim that competing in today's global economic environment requires a workforce proficient and knowledgeable in the mathematics, science, and technology fields (Romberg, 1997).

According to Romberg (1997), our schools are not preparing students for the future. Most students are poorly prepared to participate meaningfully in higher education, at work, or in their personal lives. Problems exist in traditional school mathematics with rigid teaching methods, repetitive curriculum, and the inclusion of more topics than any other country (Battista, 1999).

The Third International Mathematics and Science Study (TIMSS) revealed similar findings. Significant problems exist with student achievement and traditional mathematics curriculum in the United States (Schmittau, 2004). TIMSS, the most ambitious cross-national educational research study ever conducted, compared over half a million students' achievement

scores in mathematics and science across 5 continents and 41 countries (Schmidt & Valverde, 1997). In a comparison of U.S. students' achievements in mathematics to students of other TIMSS countries, the U.S. did not fare well. In general, the achievement of U.S. students was disappointing. The average score of U.S. eighth-grade students was below the international average in mathematics (TIMSS, 1996). In fact, the U.S. students' achievement gains never placed them in the top 25% of the participating countries in any content area. In addition, the U.S. was the only country that did not place among the top performing countries in achievement differences for any of the mathematics or science content areas for either third to fourth or seventh to eighth grade differences, illustrating that U.S. children differed very little in achievement between third and fourth grades and between seventh and eighth grades (TIMSS, 1998).

In a 2003 assessment, TIMSS, now known as Trends in International Mathematics and Science Study, the average mathematics score of U.S. fourth-grade students exceeded the international average for the 25 participating educational systems. They outscored students in 13 educational systems; however, they were outperformed by students in 11 educational systems. The U.S. eighth-grade students exceeded the international average for the 45 participating educational systems. They also outscored students in 25 educational systems, but were outperformed by students in 9 educational systems (IES National Center for Educational Statistics, 2010).

In the 2007 assessment completed by TIMSS, the average mathematics score of U.S. fourth graders was higher than those in 23 of the 35 countries, but lower than 8 other countries and not measurably different from the average scores of students in 4 remaining countries. The average mathematics score of U.S. eighth-grade students was higher than those in 37 of the 47

countries, but lower than in 5 countries and not measurably different from the average scores of students in the remaining five countries (IES National Center for Educational Statistics, 2010).

When Hiebert (1999) examined student achievement in mathematics, he found traditional teaching approaches were lacking and did not provide students with opportunities to achieve conceptual understanding. Hiebert stated that U.S. students in the traditional mathematics classroom setting have more opportunities to learn basic calculation procedures, terms, and definitions. However, students have not learned how to investigate or to theorize solutions and answers to enable them to gain self-confidence in solving complex problems. Little emphasis has been given to communicating and using mathematical ideas; the kind of mathematics that facilitates students' application of what they are learning to real-world experiences (Schoenfeld, 2002).

Hiebert (1999) also found evidence indicating traditional instructional methods and mathematics curriculum were not serving students well. In fact, a large number of students have failed or have left mathematics. Unfortunately, a disproportionate number of these students were students of color (Schoenfeld, 2002). Dissatisfaction in student achievement, teaching and content deficits, and equity issues all contributed to the call for reform in mathematics (Romberg, 1997).

Since the 1980s, a plethora of whole school models of reform, district-wide reforms, and state or national reform initiatives in mathematics have been created. At the state level there has been an escalation of effort and resources directed toward large-scale reform (Fullan, 2001). Dozens of state and individual efforts have been initiated in recent years. Many of these initiatives advocated the development of new curricula, professional development for teachers, and other initiatives, on both. Technology in mathematics instruction has been the central idea of

several initiatives (Edwards, 1994). All of the reform initiatives in mathematics have as their central objective, increasing student achievement.

Successful educational reform depends on changing teachers' beliefs, their thinking, and what they do in the classrooms (Fullan, 2001). Reform efforts rely greatly on teacher learning and their professional development; however, studies investigating professional development show discouraging results (Hill, 2004). Conventional professional development has been sorely inadequate in improving student achievement (Sykes, 1996). Ineffective strategies, such as relying on outside consultants for in-service training, disconnected workshops, limited time, and limited resources, plague traditional formats of professional development (Hill, 2004).

In Alabama, effective professional development became an important part of the state's mathematics reform effort. In 1999, members of the Alabama State Department of Education saw the critical need to improve the development of teacher knowledge along with math and science instruction in Alabama schools. Starting with the creation of a blue ribbon committee in 2000, a statewide initiative was launched designed to develop strategies to address the needs of teachers and the diverse needs of all students while creating challenging, high-quality mathematics instruction to meet the recommendations of the National Council of Teachers of Mathematics (NCTM). Through the direction of the Alabama State Department of Education, the committee developed the Alabama Math, Science, and Technology Initiative (AMSTI). AMSTI was created to provide recommendations on instruction, curriculum, assessment, professional development, and management of resources. The principle ideas behind AMSTI are that students learn mathematics and science best by doing mathematics and science while forming connections between the classroom activities and their daily lives (Alabama State Department of Education, 2009).

In the summer of 2002, teachers from 20 schools attended the first Summer Professional Development Institute (Summer Institute) on the campus of the University of Alabama, Huntsville (UAH). These schools were designated the first official “AMSTI schools.” Because of the need for teachers to learn in the same setting in which they teach, Summer Institute was moved from UAH to a local middle school (Alabama State Department of Education, 2009).

An AMSTI School is a school that receives all of the benefits of the initiative including extensive professional development, kits with supplies and materials, and professional support by math and science specialists at their home school at no cost. Schools that want to participate in AMSTI must consider several requirements and guidelines. Local superintendents and principals are mailed a letter from the Alabama State Department of Education informing them of the time and locations of the recruitment sessions. The principal, a math teacher, and a science teacher from a school interested in becoming an AMSTI school must attend the recruitment session in order to receive an application. When a school applies to attend AMSTI training, 80% of the math teachers, science teachers, special education teachers teaching or involved in supporting math and science instruction, and administrators agree to attend two week-long Summer Institutes for two consecutive summers and participate in additional professional development during the school year (Alabama State Department of Education, 2009).

Since 2002 over 600 schools statewide have become AMSTI schools. Approximately one-half of all schools in Alabama are official AMSTI schools. Daily, over 350,000 students receive instruction by AMSTI certified teachers. Since AMSTI’s inception, about 16,000 teachers and administrators have received mathematics and science training. Eleven colleges or universities are official AMSTI sites with partnerships with 16 institutions of higher education. At many universities where future teachers attend, they receive pre-service training similar to the

instruction teachers receive at AMSTI Summer Institutes (Alabama State Department of Education, 2009).

From 2004 through 2006, external AMSTI evaluators analyzed student achievement using data from the *Stanford Achievement Test Tenth Edition (SAT 10)*, the *Alabama Reading and Math Test (ARMT)*, and the *Alabama High School Graduation Exam (AHSGE)*. In 2007, the *Alabama Direct Assessment of Writing (ADAW)* was added to the analysis. Student achievement data for 2004 and 2005 was investigated by the external evaluator, the Institute for Communication and Information Research at the University of Alabama. Another external evaluator, the Office of Community Affairs at the University of Alabama, investigated student achievement data for 2006 and 2007 (Alabama State Department of Education, 2009).

According to these designated evaluators' findings, AMSTI is making a difference in student achievement, often dramatically. The 2007 student achievement data summarized by the evaluators confirmed the findings of the previous evaluations stating that AMSTI is having a strong impact on student achievement. AMSTI's impact on student achievement was studied after its implementation of 1 year, 2 years, 3 years, 4 years, and 5 years. According to Steve Ricks, AMSTI's Director, the *Report of All AMSTI schools Versus Non-AMSTI schools on 2007 Standardized Tests*, on every standardized test mandated by the State Department of Education, all AMSTI schools scored higher when compared to non-AMSTI schools (Alabama State Department of Education, 2009).

According to AMSTI administrators, AMSTI has received public attention nationally and internationally for its effectiveness at raising achievement scores, improving attendance and on task-behavior, and for increasing students' interest in math and science. As the largest and most comprehensive math and science initiative in the nation, AMSTI has become the leading forum

for mathematics and science education reform. AMSTI was selected as 1 of only 35 programs “that work” across the nation, according to Fortune 500 CEOs. Supporters of AMSTI continue to push to make all Alabama schools AMSTI schools (Alabama State Department of Education, 2009).

Statement of the Problem

Research has shown that mathematical literacy is necessary for most jobs now and in the future. It continues to be evident that traditional methods of teaching have failed to develop students’ competency in mathematics. Recognition of these deficiencies in education has reinforced the need for reform.

Responding to the need of mathematics education reform, individual and state reform initiatives have focused on the development of new curricula, teacher professional development, and the use of technology in mathematics instruction. In response, the Alabama State Department of Education created the Alabama Math, Science, and Technology Initiative (AMSTI) to meet the recommendations for reform by the NCTM.

Although AMSTI administrators say there are data to support that AMSTI has helped to increase student achievement in mathematics, not all schools have chosen to participate as AMSTI schools. This supporting data are provided by what AMSTI administrators refer to as “external evaluators:” the Institute for Communication and Information Research and more recently the Office of Community Affairs, both located at The University of Alabama. All published data have been distributed by AMSTI and the Alabama State Department of Education. There are no published results of studies in professional educational journals, and no other research was located supporting these claims. Therefore, the problem that needed to be

investigated is whether AMSTI's claim of being highly successful in improving student achievement in mathematics is accurate when results are collected and analyzed by sources other than AMSTI's external evaluators. Also, if AMSTI is so successful with improving student achievement in mathematics, then why are teachers at many schools not participating?

Purpose of the Study

The purpose of this study was to investigate what differences, if any, exist in academic achievement of students taught in an Alabama Math, Science, and Technology Initiative (AMSTI) structured classroom with students not taught in an AMSTI classroom as measured by the scores the students earn on the *Stanford Achievement Test Tenth Edition (SAT 10)* and the *Alabama Reading and Mathematics Test (ARMT)*. The study will explore the differences in the growth rate in mathematics achievement in fourth- and fifth-grade students who have been instructed in AMSTI classrooms with fourth- and fifth-grade students who have not been instructed in AMSTI classrooms. The study will further explore the perceptions of teachers who received AMSTI training and its relationship to their instructional strategies and student achievement. In addition, perceptions of not participating in AMSTI will be explored among teachers who have not participated in AMSTI training.

Significance of the Study

Given the importance of school mathematics reform, this study sought to add to the body of research knowledge. Because AMSTI is being advocated by the state, research measuring student achievement could help determine the appropriateness of professional development and support the further expansion of AMSTI sites. The results of this study may provide beneficial

information for teachers and administrators who are considering becoming AMSTI schools. This study could provide insight into state mathematics initiatives, the quality of their professional development, and the expectation of student achievement.

Research Questions

1. What are the differences between *Stanford Achievement Test Tenth Edition (SAT 10)* mathematics scores of fourth- and fifth-grade students who have been instructed in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and students in non-AMSTI classrooms?

2. What are the differences between *Alabama Reading and Mathematics Test (ARMT)* mathematics scores of fourth- and fifth-grade students who have been instructed in AMSTI classrooms and students in non-AMSTI classrooms?

3. What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have received AMSTI training?

4. What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have not received AMSTI training?

Definition of Terms

Alabama Math, Science, and Technology Initiative (AMSTI). The Alabama Math, Science, and Technology Initiative was developed by a committee under the watchful eye of the Alabama Department of Education. Great effort was taken to guarantee that AMSTI is research-based and integrates best teaching practices. Hands-on learning with concrete materials, inquiry

learning, and teachers' continued support are key elements of AMSTI (Alabama State Department of Education, 2009).

Alabama Reading and Mathematics Test (ARMT). A test created from the Alabama State Content Standards. The ARMT is an assessment used in Alabama schools to measure adequate yearly progress required by *No Child Left Behind* (Alabama State Department of Education, 2009).

Stanford Achievement Test Series Tenth Edition (SAT 10). Achievement tests that guide teaching and learning toward high achievement standards (Harcourt Assessment, 2007).

Scaled scores. These scores are converted raw scores that facilitates conversions to other score types and suitable for studying change in performance over time (Stanford Achievement Test Tenth Edition).

Limitations of the Study

1. Convenience sampling rather than random sampling was used in this study. This limited the generalizability.
2. The relatively small sample size of comparing fourth- and fifth-grade students in four rural schools limited the generalizability to all classrooms.
3. The small sample size of the number of fourth- and fifth-grade teachers limited generalizability to other teachers.
4. The AMSTI teachers involved in this study were trained in different years. One school's teachers were trained in 2006 and the other teachers in 2008.

Assumptions of the Study

1. The teachers involved in this study followed the Alabama Course of Study: Mathematics as a curriculum content guide.
2. The AMSTI classroom students were similar to the non-AMSTI classroom students.
3. The teachers followed the Alabama Department of Education's protocol when administering the *Stanford Achievement Test Tenth Edition* and the *Alabama Reading and Mathematics Test*.

Summary

The discussion of the study has been organized into five chapters. Chapter 1 provides an introduction and pertinent information regarding the study. Chapter 2 contains a review of the literature on the history of mathematics education, standards in mathematics, professional development, mathematics initiatives, and AMSTI. A detailed account of the methodology used in the study is contained in chapter 3. Chapter 4 presents the findings of the study. The fifth chapter includes a discussion of the interpretation and implications of the study's findings.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this study was to investigate what differences, if any, exist in achievement of students taught in Alabama Math, Science, and Technology Initiative (AMSTI) structured classrooms compared with students not taught in AMSTI structured classrooms. The study is centered on students in fourth- and fifth-grade classrooms. The study also will look at the effects of AMSTI mathematics professional development on participating teachers' instructional strategies and investigate elementary teachers' perceptions of the AMSTI's math component. The literature review includes sections on (a) elementary mathematics education, (b) professional development, (c) mathematics initiatives, and (d) the Alabama Math, Science, and Technology Initiative.

Elementary Mathematics Education

History of Math Education

Mathematics education has been viewed as the foundation of our nation's scientific and technological competence (Schoenfeld, 2002). In our society, education has been perceived to be the means for social and economic advancement. Research suggests that high levels of mathematical and technical skills are needed for most occupations in the future (Xin, Jitendra, & Deatline-Buchman, 2005).

With so much emphasis placed on mathematics curricula in the U.S., periodically it becomes the focus of national attention (Schoenfeld, 2006). In fact, during the past 50 years there

have been three major shifts in mathematics curricula in the United States. Scientific and mathematically based changes brought about the first major shift. In the 1940s, the role science and mathematics played in the development of atomic weapons and the showing of technological advancement by the Soviets were a “wake-up” call in the U.S. (Woodward, 2004).

In 1957 the Soviets’ launching of the first satellite, Sputnik, shocked America and initiated the first curricular shift. Clearly, the U.S. had fallen behind in mathematics and science achievement, and the curricula in our elementary and high schools were responsible (Knuth & Jones, 1991). In response to the USSR’s launching of Sputnik, a modern era of reform began (Hochschild & Scovronick, 2003).

Americans saw the launching of a Soviet satellite as a threat, as well as a direct challenge, to their educational system (Hochschild & Scovronick, 2003). In response, critics demanded a revamping of curricula, tougher selection and training of teachers, greater regimentation in the classroom with fewer “frills,” and a renewed attention to patriotism (Tyack & Cuban, 1995). To meet these changes, many U.S. mathematicians and scientists convened to develop new math and science curricula and instructional programs (Knuth & Jones, 1991).

The need for change in the educational system also was being felt in colleges and universities. Educators were apprehensive about the inadequacies of the mathematical programs in the K-12 school systems. Enrollment in their mathematics classes was declining, and many believed that students entering their colleges lacked adequate computational skills and mathematical understanding as well as the ability to apply their knowledge to other disciplines. These concerns in the K-12 and collegiate systems were key reasons behind a push for excellence in education. With this emphasis on excellence, large-scale federally funded curriculum reform projects, such as the University of Illinois Committee on School Mathematics,

University of Illinois Arithmetic Project, and the School Mathematics Study Group, were created (Woodward, 2004).

An immediate goal of the reform was to increase the number of engineers, scientists, and technically skilled workers needed for a more scientifically-based society. The newly created mathematics and science programs were funded extensively by the federal government, and this concentration of effort and surge of federal funds produced more scholars, teacher educators, and skilled mathematics teachers trained to enable the United States to compete globally (Woodward, 2004).

The result of this emphasis placed on mathematics in the late 1950s and 1960s was the creation of *New Math*. The *New Math* curricula broke with the traditional emphasis placed on skill and drill of the behaviorist era and concentrated on aspects of a highly abstract and conceptual focus (Knuth & Jones, 1991; Schoenfeld, 2006; Woodward, 2004). The *New Math* was to establish the principles and concepts of mathematics needed from early grades and onward to include proof, structure, generalization, and abstraction (Woodward). The themes associated with the educational change such as altering the curricula, child-centered pedagogy, social reform, and self-liberation, which were identified with the progressive movement decades earlier, reappeared in the late 1960s (Cuban, 1993).

For several reasons America did not fully embrace the *New Math* (Knuth & Jones, 1991), and as time progressed, it failed (Woodard, 2004). The mathematics community had no agreement as to its value as well as the goals of *New Math* were not understood by the teachers, administrators, boards of education, and other policymakers (Price, 1995). Many of the innovations, such as open classrooms and discovery learning, lacked rigor in design and evaluation (Hochschild & Scovronick, 2003). And, importantly, the impact on improving student

achievement in mathematics was less than expected (Knuth & Jones). Because it was known for its top-down attempts at development and implementation, teachers were not given support as they worked to re-conceptualize their own understanding of mathematics. This lack of appropriate professional development needed for support of the K-12 teachers was an important part in the demise of the *New Math* (Woodward).

The second curricular shift was another reason the *New Math* failed (Woodward, 2004). In the early 1970s, the impetus to return to the “3 R’s” resonated through the educational community (Knuth & Jones, 1991). Many educators were fearful that education had gone “soft” in the late 1960s and had moved too far away from the “basics” in the curriculum, losing sight of the real purpose of schools. Business leaders criticized schools for ill-preparing the high school graduates for employment (Woodward). Educators in disadvantaged areas claimed their students lacked basic skills; the *New Math* did not serve their children’s needs and was more of a lip-service than genuine support (Fain, Shostak, & Dean, 1979; Woodward).

As problems prevailed, American education moved out of the “soft sixties” into the “responsible seventies” (Fain, Shostak, & Dean, 1979). In this *Back to the Basics* curricular shift, greater emphasis was placed on reading, writing, and arithmetic. Teachers were once again considered to be the dominant figure in the classroom, and extras, such as art, social services, and sex education were reconsidered as part of the curriculum (Woodward, 2004). Classroom practice consisted of a teacher-centered pedagogy with total-group instruction, classroom talk, and class activities directed by lecture-discussion and whole-group instruction (Cuban, 1993). Hirsch (1996) referred to this approach to teaching as the “factory model” where students think as they are told to think. They merely parrot back memorized mathematical facts without understanding them, and are unable to manage new situations and new knowledge.

Educational research in the 1970s and early 1980s reflected the results of the *Back to the Basics* movement. Studies such as the Missouri Mathematics Effectiveness Project investigated the relationship between teaching or process, and student achievement, being the outcome or product. Research acknowledged the efforts by educators to improve their understanding of basic skills instruction in elementary school. In this process-product environment experimental, rather than descriptive, statistics became the dominant choice of educational research. Standardized tests scores became important to educational research, and accountability became the current cliché as these tests became a critical guide states used to evaluate the quality of their schools (Good, Grouws, & Ebmeier, 1983).

The third curricular shift occurred in the late 1970s. The longstanding behaviorist principles were overshadowed by the theory of cognitive science--the study of the mind (Knuth & Jones, 1991). Researchers and educators relied on cognitive science as the foundation for mathematical investigations (Woodward, 2004). A central theme of cognitively based research is the explanation of the nature and importance of understanding, where understanding is the assimilation of new information into the students' prior knowledge (Knuth & Jones).

The theory of cognitive science resulted in a change of the view of math from the traditional rote-memorization of numbers and computation to math as problem solving. Research was beginning to demonstrate the importance of children's development and teaching for mathematical understanding where students actively construct knowledge by doing and problem solving rather than skill development. Researchers focused on how children's prior knowledge, their out-of-school experiences, informal mathematics knowledge, and the knowledge and beliefs of the teacher were interrelated. Evidence showed that teaching for mathematical understanding did not lead to the weakening of mathematics skills; rather, students' ability in mathematics

skills depend upon their understanding. Teaching for understanding helped students to retain knowledge and apply that knowledge to new mathematical situations (Knuth & Jones, 1991).

Reform Movement in Schools

In reaction to the acknowledged failure of traditional methods of teaching mathematics, a movement toward educational reform began. A major shift in philosophy occurred in education driven by the forces of scientific study in mathematics education and the computer age (Battista, 1999). This reaction led to the formation of committees and publishing of documents outlining important mathematical pedagogy, curriculum, and assessment practices. In 1983, the National Commission on Excellence in Education published *A Nation at Risk* and the National Science Board Commission, in the same year, published *Educating Americans for the Twenty-First Century*. Authors of both documents claimed that competing in a global economic environment required a labor force proficient and knowledgeable in mathematics, science, and technology (Romberg, 1997).

In 1984, in support of the vision and strategies for mathematics reform identified in these documents, President Reagan called for tougher standards in mathematics and science, renewing a commitment to excellence in education (Hess & Rotherham, 2007). With a fear of a “rising tide of mediocrity” in education and a desire to create “world-class” school mathematics, *A Nation at Risk* defined what students should know and be able to do (Vickers, 2006). According to Shanker (1995), *A Nation at Risk's* mission for public education was to prepare America’s youth for democratic citizenship and to promote individual as well as national prosperity. Also, an important concept was its clarity about why education reform is necessary: average student

achievement. Thus, *A Nation at Risk* was credited with launching the modern standards movement (Lefkowitz & Miller, 2006).

By the 1990s, however, the power of *A Nation at Risk* faded. *America 2000*, the educational reform program of the first Bush administration, was born. *America 2000* was anticipated to do what the curricula reform, the accountability reform, and *A Nation at Risk* were unable to achieve in the previous 20 years. *America 2000* was transformed by the Clinton administration into *Goals 2000*. *Goals 2000* was the new education reform effort for revising teacher certification, curricula content, and formulating new national standards that described what students should know and be able to do (Eisner, 1995).

Coinciding with *Goals 2000*, the National Research Council published a report on the future of mathematics education, *Everybody Counts*. The report identified students' lack of preparation for tomorrow's jobs and recommended the development of new curricula relevant to the mathematical needs of the 21st century (Alper, Fendel, Fraser, & Resek, 1997; National Research Council, 1989).

The NCTM Standards

In response to this need for reform and publications and reports, the educational community and the National Council of Teachers of Mathematics (NCTM) vigorously organized committees, conducted conferences, and created a plethora of documents on mathematics curriculum, teaching, and assessment practices, and the general reform vision of developing "world-class" school mathematics (Romberg, 1997). In a 10-year period NCTM researched, developed, and revised a set of fundamental standards (Jennings, 1995; Lewis, 1995). The publications, *Curriculum and Evaluation Standards for School Mathematics* in 1989, the

Professional Standards for School Mathematics in 1991, and in 1995, the *Assessment Standards for School Mathematics* were designed to promote essential changes in the curriculum, instruction, and mathematics assessments. These standards were to reinvent mathematics classrooms of the 21st century so they would have little resemblance to the mathematics classrooms of the 1990s. The Standards were considered as benchmark statements about specific facets of curriculum, materials, and instruction, and by 1996, they were widely accepted throughout the country (Cauley & Seyfarth, 1995).

Forty-nine states and numerous local school districts used the NCTM content standards' recommendations in creating their own mathematics curriculum standards. The National Science Foundation (NSF) played an important role when it funded various comprehensive curriculum development projects that brought about the development of standards-based curricula for elementary, middle, and high school mathematics. In further support, the NSF also funded professional development projects that focused on building and enhancing teachers' abilities and knowledge to implement standards-based reform in the classrooms (Martin & Berk, 2001).

The NCTM standards addressed not only the content and process of what is to be taught in mathematics, but also what it means to be mathematically literate (Schoenfeld, 2002). Romberg (1993), the chair of the commission charged with creating *Curriculum and Evaluation Standards for School Mathematics*, declared the Standards were created as a product of scholarly review and analysis involving the consensus of many groups while using its own resources free of any influence from governmental agencies or corporate groups. And, over the next decade, goals of the Standards were developed and refined, which produced a more solid research-based document than the original Standards; thus, in 2000, the creation and publication of *Principles and Standards for School Mathematics (PSSM)* (Schoenfeld).

The *PSSM* published by the NCTM supported greater student learning in mathematics (Trafton, Reys, & Wasman, 2001). The document called for the development of a core curriculum that is responsible for the mathematical literacy of all students, whether preparing for the workplace or college (Schoenfeld, 2002). It also called for emphasis on reasoning, problem solving, communicating, and making connections with the students' lives outside the mathematics classroom; classrooms where students are encouraged to explore, hypothesize, and correct errors while solving complex problems (Alsup & Sprigler, 2003; Friesen, 2006). The standards are built upon the principles that designate the characteristics of a high-quality mathematics education. The six principles highlight a stance on equity, curriculum, teaching, learning, technology, and measurement of what is to be learned (NCTM, 2000).

The *PSSM* provides guidelines for teacher decision making. A teacher in a standards-based classroom chooses worthwhile mathematical tasks, facilitates and monitors classroom discourse, creates a classroom environment for learning, and analyzes one's practice (NCTM, 2000). The teacher considers the content and process of doing mathematics with four basic standards: mathematics as problem-solving, as reasoning, as communication, and mathematics as connections-linking mathematics with the real-world (Cooney, 2003).

Over the years there have been several research studies focused on investigating the impact of the NCTM standards. Some of these studies investigated classrooms using the first NCTM standards while other studies investigated classrooms using the revised standards.

Trafton, Reys, and Wasman (2001) identified specific characteristics of standards-based classrooms. These classrooms should reveal (a) curriculum focused on core mathematics with broad themes and mathematical content that is designed with math processes in mind, (b) standards-based materials that are engaging and motivating to students, (c) comprehensive and

coherent materials with core mathematical ideas structured where students are able to see the integrated whole rather than skills in isolation, (d) in-depth development of math ideas with connections and sense-making, and (e) student involvement through problem solving and manipulatives.

The support for standards-based reform in the classroom has been documented by other research studies (Bay, Beem, Reys, Papick, & Barnes, 1999; Fuson, Carroll, & Drueck, 2000; Manouchehri & Goodman, 1998; Riordan & Noyce, 2001). Manouchehri and Goodman studied and evaluated the implementation of four standards-based curricular materials of over 60 middle school mathematics teachers from 12 rural, suburban, and urban school districts in the state of Missouri. Data collection methods included observations of teachers' classroom instruction, field notes, researchers' logs, individual and group surveys, and interviews. After 5 months of implementation nearly all the teachers reported an increase of student interest in learning mathematics and greater student involvement in class activities all resulting from the use of standards-based materials.

In another study using standards-based curriculum, *Everyday Mathematics* was used that involved two studies. *Everyday Mathematics* is a National Science Foundation mathematics curriculum based on the NCTM Standards and created by the University of Chicago School Mathematics Project. It is the mathematics curriculum in over 175,000 classrooms for over 2.8 million students. In the first study, test results of 392 second graders in 22 different classes were used, and in the second study 620 third graders in 29 classes participated. The same group was followed from second grade to third grade. Two hundred thirty-six students were part of the original first-grade sample. Their scores were used as the focus of this study, and the analysis of the data showed positive results supporting a standards-based approach to teaching mathematics

when compared to the NAEP comparison group. Both studies showed students can perform better with standards-based curriculum than with traditional curriculum approaches (Fuson et al., 2000).

Riordan and Noyce (2001) conducted a study with approximately 9,000 fourth-grade and eighth-grade students. The data showed that students' use of standards-based mathematics curriculum projects had a positive impact on student achievement. According to the Massachusetts Educational Assessment Program and Massachusetts Comprehensive Assessment System, students who used standards-based textbooks outperformed students who were using textbooks that were not standards-based. Duration had an influence on student performance, also. In schools where implementation of the program was farther along, students had a higher achievement level when compared to the other students.

Bay et al. (1999) asked over 1,000 students to write a letter reflecting on their mathematical experiences using standards-based curriculum. The students were not given directions on what to write in their letters. After the letters were read, coded, and analyzed a particular emphasis was discovered. Students' responses included an increase in real-life application of mathematical strategies along with hands-on activities using the new curriculum. Also, the responses in the letters showed that students believed they were learning important mathematics while being challenged and having fun when they used the standards-based curriculum.

The development of the mathematics standards by NCTM came at a time when President George Bush's administration was searching for rigorous content standards that would enable the U.S. to excel in math and science. It was apparent the educational system needed to produce

knowledgeable workers who were proficient in the use of technology and communication skills and who had developed a high level of mathematical literacy (Woodward, 2004).

Contributing Factors for Reform

Another factor that amplified the need for mathematics reform and the importance of developing educational excellence in mathematics was the Third International Mathematics and Science Study (TIMSS). In 1995, an assessment was conducted in six grades of 41 countries. Unfortunately, the U.S. scored in the middle ranking, falling behind Asian countries (TIMSS, 1995; Woodward, 2004). In 2003 and 2007 assessments conducted by Trends, U.S. students in fourth grade and eighth grade scored below five or more educational systems that participated in the assessments (IES National Center for Educational Statistics, 2010).

The TIMSS report suggested that American curricula were at least part of the problem. U.S. curricula were viewed as more skills oriented, more repetitive, and less conceptually deep than curricula of nations that scored better (Schoenfeld, 2006). The famous saying “a mile wide and an inch deep” was a creation of the TIMSS research that was used to describe the U.S. mathematics curricula. Also, of the countries that were more successful on the assessment, teachers’ mathematical abilities were a core theme. These effective teachers knew mathematics deeply and conceptually, and they understood how to explain mathematical concepts to their students. Their instruction was conceptual, not based on rules and algorithms (Woodward, 2004).

According to Woodward (2004), it was time of significant progress in mathematics education and research, more so than at any point since the *New Math* era 30 years earlier. Mathematics research moved from a cognitive and information processing orientation to a constructivist viewpoint. Constructivists attempted to show how learning developed in context

while researchers sought for insight into peer and group learning and understanding the role language played in teaching and learning.

The turn of the century brought new challenges in education. The state of mathematics education and research in the U.S. reflected the conflict between reform and the politics associated with accountability (Woodard, 2004). Then in 2001 the NCLB act was established. It was the result of 15 years of standards-based reform, and the outcome is accountability based on mandated testing, which is now the standard in public schools (Jennings & Rentner, 2006). President George W. Bush's administration introduced NCLB and the term scientifically-based research as the way to select the best instructional practices for America's classrooms (Woodard). Jennings and Rentner stated that one major effect of NCLB has resulted in more time being spent in schools on mathematics and reading.

NCLB called for "greater responsibility" for student learning from teachers and schools (LoGerfo, 2006). The enactment of NCLB restructured the Elementary and Secondary Education Act by raising the academic achievement standards for America's children in kindergarten through high school (Ashby, 2006). Designed to improve the academic performance of the disadvantaged and minority students, the new law was created to change the culture of public schools in America (No Child Left Behind Act, 2002). NCLB was structured around these principles: (a) annual testing in Grades 3 through Grades 8 and at least once in high school to track student progress and accountability; (b) greater flexibility for states and districts by permitting school districts to spend certain federal funds on needed programs; (c) utilizing research-based teaching strategies; (d) more school choices for parents such as offering free tutoring for children in low-performing schools and the opportunity to transfer students to higher

performing schools. *No Child Left Behind* established a historic, challenging, vision for the country: every child performing at grade level in reading and math by 2014 (Ashby).

If this vision is to be accomplished, educational reform is necessary, and professional development is deemed central to reform in mathematics and science education (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). Professional development where teachers learn is critical for student achievement. Leaders in educational reform initiatives support the idea that schools must be places where both teachers and students learn (Smylie, 1995). Schools should be places that facilitate teachers in their development as they practice the art of teaching (Bonner, 2006).

Professional Development

The call for better professional development is unanimous because more teachers are needed who are skilled in teaching challenging standards and who help all students learn. Professional development that targets improving student achievement is a worthwhile investment (Loucks-Horsley & Matsumoto, 1999). Guskey and Sparks (1996) proposed that student achievement outcomes are improved through the relationships among quality staff development and teachers', administrators', and parents' knowledge and practices and the many factors influencing each of these components.

Loucks-Horsley, Hewson, Love, and Stiles (1998) stated that mathematics and science education reform depends firmly on a commitment to change the form of teaching and learning that is currently the norm in U.S. classrooms. Teachers need new knowledge, skills, behaviors, and dispositions to achieve the new vision of reform. They need opportunities for professional

growth which gives them a chance to learn what they need to know in ways that model how they can work with their students.

Professional development is a crucial element of mathematics and science education reform and has remained a key strategy in educational reform (Loucks-Horsley et al., 1998). The accountability movement in the U.S. has increased the pressure on districts and schools to provide professional development specifically targeted toward improving student achievement (Huffman, Thomas, & Lawrenz, 2003).

Professional development has been defined as the opportunities offered to educators to develop new knowledge and skills, refine instruction, and change dispositions to improve their effectiveness in their classrooms (Loucks-Horsley et al., 1998). Guskey (1986) referred to professional development as an organized effort to change teachers with the expected result of improving their instruction and student achievement. Professional development has also been described as a multidimensional process that encompasses all aspects of training, from readiness activities, practice and coaching, through follow-up and support activities (Guskey & Sparks, 1991).

Research on professional development underscores the need to help teachers understand learners and learning, subject matter, and teaching methods. With these needs in mind, there are consistent guidelines for planning and implementing professional development evidenced by research that may bring about reform and improvement of practices in classrooms (Richardson, 2003). Researchers have identified various components of these guidelines including the following: (a) participants, (b) content and pedagogical knowledge, (c) duration, (d) resources, (f) follow-up, and (g) evaluation (Birman, Desimone, Porter, & Garet, 2000; Darling-Hammond

& McLaughlin, 1995; Guskey & Huberman, 1995; Lee, 2001; Loucks-Horsley et al., 1998; Loucks-Horsley et al., 2003; Loucks-Horsley & Matsumoto, 1999).

Because teachers are the primary participants of professional development, research and practices have generated a mass of working ideas about teachers and teacher learning. Various studies have identified a range of characteristics supporting professional development that brings about change in the classrooms. For example, effective professional development should be driven by a well-defined vision of what successful classroom teaching and learning represents. The focal point of professional development must be on improving teachers' understanding of the processes of teaching and learning as well as understanding the students they teach (Ball, 1996; Loucks-Horsley et al., 1998; Loucks-Horsley et al., 2003).

Darling-Hammond and McLaughlin (1995) stated that effective professional development that brings about change in practice engages teachers in two modes: one as a learner and one as teacher. This allows teachers to struggle with the uncertainties that come with both roles. Birman et al. (2000) stated that it is critical that staff development provide the information and opportunities necessary to promote teacher learning and change in practice.

Professional development must involve teachers in the tasks of teaching, assessment, and reflection that clarify the process of learning and development. It must be based on teachers' work with their students and grounded in inquiry, experimentation, and reflection that are participant-driven. An example of a participant-driven program took place in a Michigan school. The project was based on the principle that classroom teachers can best address their needs by identifying their priorities and planning collaboratively. In a 3-year study of the Staff Development for School Improvement project, major improvements began to occur when the staff began to work together on instructional issues. With social interactions in committee

activities and other gatherings, teachers created an atmosphere of collegiality. The success of this study demonstrated that teachers can be a powerful force when they are allowed to participate in problem solving and responsible decision making (Sparks, Nowakowski, Hall, Alec, & Imrick, 1985).

Through modeling, effective professional development experiences provide opportunities for teachers to use the strategies they will use with their students. It must involve teachers in the modeling, coaching, and collective resolution of problems of practice (Loucks-Horsley et al., 1998). It poses the teacher as the student where learning occurs by doing, reading, and reflecting just as their students do. Teachers learn while collaborating with other teachers, looking closely at students and their work, and by sharing what they observe (Darling-Hammond & McLaughlin, 1995).

Similar to Darling-Hammond and McLaughlin (1995), Loucks-Horsley et al. (1998) stated that effective professional development must encourage collegiality and collaboration where knowledge is shared among a community of educators rather than on individual teachers (Anderson, 1995; Viadero, 2005). The Alabama State Department of Education agreed and stated in the Alabama Standards for Professional Development Code (Appendix A), effective professional development organizes personnel into learning communities whose goals are aligned with those of the school, the system, and the state (Alabama State Department of Education, 2009). According to Bay et al. (1999) and Guskey and Huberman (1995), collaboration with colleagues is imperative. True collaboration is more than planning lessons together, it includes having the opportunity to share stories and to discuss problems and issues in depth. It should be structured around a community of learning where learning is a part of the

school customs and culture where teachers are rewarded and encouraged to take chances with their learning, and share their knowledge with others.

A good example of collaboration is the Middle Grades Mathematics Renaissance project. As a systemic initiative, Renaissance was designed to change middle-grades' mathematics. The goal of Renaissance was to create professional development that would essentially transform middle-grade mathematics by helping teachers meet the demands of reform. Having reached 40% of California's middle schools, Renaissance fostered communication in individual schools about the teaching and learning processes. Teachers participated in a system of educators that provided momentum and widespread support for change (Acquarelli & Mumme, 1996).

Along the same idea, Viadero (2005) pointed out that it is important for teachers to engage in collaborative learning with other teachers from the same department or grade level. This could encourage them to meet and reflect on what they have learned. Supporting this idea, a longitudinal study that involved a national evaluation of professional development was conducted by Eisenhower Professional Development-Title II of the Elementary and Secondary Education Act, which included a representative sample of 1,027 teachers nationally. The teachers were surveyed over a 3-year period to determine the relationship between professional development and their classroom practice. The results of the study identified various characteristics of effective professional development including the amount of time or duration of the activities, content focused, teachers actively learning, with emphasis on collective participation of teachers from the same school, grade level, or departments, and professional development that is consistent with classroom learning (Birman et al., 2000; Desimone, Porter, Garet, Yoon, & Birman, 2002).

Professional development must provide a variety of opportunities that allow teachers to share what they know, discuss what they want to learn, and form connections with their learning to the context of their teaching (Darling-Hammond & McLaughlin, 1995). The findings in the study, Integrating Mathematics Assessment (IMA), supported the idea of professional development being consistent with what is happening in the classroom, also. The study found that new knowledge acquired during professional development is more likely to be integrated into the classroom when it is connected to the curriculum already in the classroom (Gearhart, 1991).

Fullan and Miles (1992) declared that teachers must maintain an active part of the reform process. Change is always executed by teachers in the classroom and by involving them they are more likely to assume ownership. The teachers at Holbrook, a Michigan school, developed a strong sense of ownership through their staff development program. The Staff Development for School Improvement program was supported through a grant from the state of Michigan. Teachers participated in the program by examining state assessments, developing more effective teaching techniques, and participating in individually designed professional growth activities. Success of the program was measured quantitatively by state assessments. Students showed a significant improvement in their test scores. Teachers believed the students' success resulted directly from the staff development project. Other success included improved communication among staff members, higher staff morale, and greater interest in trying new teaching techniques. As a final benefit the project created a sense of staff ownership of the school and its programs (Sparks et al., 1985).

Birman et al. (2000) agreed by saying teachers have a central role in making standards-based reform successful; therefore, they must be included in the planning and process. Sykes

(1996) also saw the need to involve teachers in the process of professional development to bring about reform, but stated that they exert relatively little control over a system that is deeply institutionalized in a pattern of organization, management, and resource allocation. Fullan (2001) concluded that it is important to consider and remember that ultimately it is up to the teachers to make the choice to implement change or not.

Successful implementation of research-based practices depends greatly on professional development with a concentration on teachers' content and pedagogical knowledge (Basista & Mathews, 2002; Viadero, 2005). This was Gearhart's (1991) focus with a study using the Integrating Mathematics Assessment (IMA) program, with children's mathematical thinking as a focal point. The study focused on the content knowledge teachers needed to teach fractions and measurement with upper elementary students and the professional development needed to accomplish this goal. The findings of the study indicated that building teachers' content knowledge along with understanding students' mathematical thinking can improve classroom practices and increase students' mathematical skills. Effective teachers must have in-depth knowledge of the subject matter and the way students build their understanding as they work through problems. Teachers need to examine their students' thinking as they work through their lessons and build upon their thinking and understandings. When teachers know mathematics in-depth and the ways children learn, they are more likely to teach in this way. As their content knowledge becomes more in-depth, they come to understand the importance of knowing what students know, a critical component of effective classroom practice.

Effective professional development experiences provide opportunities for teachers to build their knowledge and skills. Research conducted by Birman et al. (2000) indicated that professional development opportunities should focus on teachers' understanding their

mathematical content and knowledge of how students learn the content. Teachers should be provided opportunities for actively learning with coherence in their professional development experiences. In the Standards for Staff Development, the National Staff Development Council (NSDC) supported this idea when it called for professional development that sustains and builds teachers' content knowledge. The NSDC's primary purpose is to make professional learning available that results in achievement for all students (NSDC, 2007).

Effective professional development helps teachers develop in-depth knowledge of their disciplines as well as pedagogical knowledge (Loucks-Horsley et al., 1998). Teachers are unable to help students understand what they themselves do not understand; thus, knowing the content deeply is the key to learning how to teach subject matter so all students understand it (Loucks-Horsley & Matsumoto, 1999). In fact, a study conducted by Harvard economist Ronald Ferguson involved 900 Texas districts and found that teacher expertise accounts for 40% of the differences in students' scores on math and reading tests (Viadero, 2005).

Darling-Hammond and McLaughlin (1995) supported this idea when they stated that teachers need to understand subject matter deeply and flexibly so students can connect ideas to one another, form cognitive maps, and address any misconceptions the students may have. Teachers need to see how concepts connect to everyday life and teach these connections to their students. The core assumption underlying the work of the study, Integrating Mathematics Assessment (IMA) program, was that students profit when their teachers understand the mathematics content they are teaching and the sense their students are making of the mathematics (Gearhart, 1991).

Basista, Tomlin, Pennington, and Pugh (2001) reiterated that teachers need a deep understanding in their disciplines, but pointed out that middle school teachers often lack the

content preparation and pedagogical foundation to effectively implement teaching practices recommended by the national science and mathematics education standards. To address these needs, an integrated mathematics and science professional development program was created in 1997 by Wright State University mathematics and science educators in collaboration with two school districts in Ohio. The study was funded by Eisenhower Professional Development Programs and the National Science Foundation Project GROW. It was based upon the framework of Project DISCOVERY, which modeled inquiry and cooperative teaching methods and gave teachers opportunities to develop inquiry lessons for their classrooms. The integrated mathematics and science program consisted of an administrator workshop, a 4-week intensive summer institute, follow-up seminars, with classroom visitations and support. Using Physics by Inquiry content modules, teacher participants showed significant content knowledge average gains of 61% from pretests and posttests. Through questionnaires, significant gains were demonstrated in their abilities and confidence to implement integrated inquiry teaching practices in their classrooms.

Darling-Hammond (1998) agreed that the expertise of a teacher is one of the most critical factors in student achievement. Teachers who understand how to teach and how students learn and who are encouraged to know their students are all significant elements to successful learning. According to Ball (1996), mathematics and science reform initiatives are being challenged to increase the subject content and pedagogical content understanding of the teachers to enable student learning. However, Guskey (1986) said student learning is unlikely to increase without change in participants' knowledge, skills, pedagogy, and, eventually their attitudes and beliefs.

Along with content and pedagogical understanding, the duration of the professional development is also a vital component to consider. Little (1993) found that traditional professional development has been in the form of in-service workshops and largely of short duration. Lieberman (1995) confirmed Little's ideas and stated that staff development normally takes place primarily at a series of workshops, conferences, or with help from a consultant. Indeed, most of the professional development that takes place derives from short-term transmission models that pay no attention to what is already going on in the classroom, school, or district, offering little opportunities for participants to become involved in the activities and without any further follow-up (Lee, 2001; Richardson, 2003).

Loucks-Horsley and Matsumoto (1999) said the idea is to move away from traditional professional development that occurs in a one-shot session where teachers are confronted with topics that are not connected to their learning or teaching going on in the classroom. They are not given the opportunity to study their content matter deeply. Darling-Hammond and McLaughlin (1995) continued by stating that professional development should depart from old customs and models of pre-service or in-service training. It should create new images of what, when, and how teachers learn.

Research conducted by Birman et al. (2000) indicated that activities of longer duration tend to focus more on subject-area content, provide more active learning, and more consistency with teachers' classroom experiences than do shorter activities. A professional development activity called Project Science was conducted in Middle City, Wisconsin. It continued throughout a full year. The project included a summer institute, 2-hour monthly meetings, and networking sessions focused on curriculum and learning issues. In these meetings, teachers

shared their progress, difficulties, ideas, and needs. The success of Project Science demonstrated how extended duration facilitated teacher and student learning.

Viadero (2005) agreed by stating longer-lasting professional development tends to yield positive results in the long run. Huffman et al. (2003) added that professional development for teachers should include a longer duration of active engagement, content that is connected to teachers' work and their students' learning, and opportunities for the teachers to practice and apply what their students learn in a real-world context. In a study conducted by Huffman et al. (2003), 94 middle school science teachers and 104 middle school math teachers were involved. The study examined the correlation between a variety of professional development opportunities, what teachers do in the classroom, and the academic achievement of students in mathematics and science. Data determining what teachers do in the classroom and the type and amount of professional development the teachers received were collected through teacher surveys. Mathematics and science achievement tests were used to measure student achievement. The study found that teachers participated in professional development when it was structured around or was related to local school-based curriculum that occurred in their classrooms.

Professional learning for teachers should emphasize a long-term, active engagement (Huffman et al., 2003). Professional development must allow teachers to engage actively in collaborative experiences that progress over a longer period of time (Darling-Hammond & McLaughlin, 1995). Professional development initiatives that are designed with reform in mind must pay close attention to implementation for several years for teachers to progress from an early focus on management to a later focus on student learning. Teachers must have protected and structured time to learn and develop new curriculum, try it in their classrooms, and reflect on

their experiences and those of their students. Most research takes 3 to 5 years for teachers to develop a routine of using a new program (Loucks-Horsley et al., 1998).

In an effort to transition from traditional professional development to professional development that supports reform, highly competent mathematics and science specialists have been involved in the process of immersing teachers in mathematics problem solving and scientific inquiry through programs that improve teachers' understanding of their curriculum. These programs must emphasize a commitment to reforming teaching and learning, and understanding that implementing curriculum takes time, and the use of adequate resources (Knuth & Jones, 1991; Loucks-Horsley et al., 1998).

Adequate resources are another component to be considered with professional development. Materials and services should be available that support reform efforts. Teachers need standards-based instructional materials specifically connected with the activities in the classroom and grounded in the professional development (Briars, 1999). Bay, Reys, and Reys (1999) found in their study that teachers also need the opportunity to "try out" the materials and curriculum. Trying them out is an important factor to help each teacher become familiar with the curriculum and materials recommended for instruction. Using these resources offers the same experiences for teachers to share through collaboration--the key to assisting some teachers in the use of the materials; they were able to determine what materials work best and the pacing of the activities and units of study.

Follow-up with the participating teachers is another important part of effective professional development (Ball, 1996). Lee (2001) and Richardson (2003) stated that most professional development is short-term, inconsistent with classroom activities, and is without further follow-up to the participants. In a study reported by Basista et al. (2001), teacher

participants of an integrated science and mathematics professional development program that was structured on the framework of the successful Project DISCOVERY requested more classroom support and follow-up activities. By increasing academic follow-up seminars and classroom visitation and support, teacher participants showed significant content knowledge gain of 61% on pretests and posttests and significant gains in abilities and confidence to implement science and mathematics inquiry teaching practices in their classrooms.

When professional development programs create an environment that assists and supports teacher learning, and when the program continues to support teachers in their challenges to integrate new concepts and instructional strategies into their ongoing educational programs, then teachers can expand and elaborate on their professional knowledge base and can begin to teach in ways supported by reform (Guskey & Huberman, 1995). Joyce and Showers (2002) agreed and suggested that professional development be sustained by coaching and technical support guiding teachers in adapting the new practices involved with reform.

In a study conducted by Becker (2001), classroom follow-up through coaching was central to the professional development program. The study was ongoing during 2000-2001 academic years and used qualitative data derived from observation techniques. The study was designed to determine the impact classroom coaches could have on improving instruction in elementary mathematics classrooms by meeting individual needs. This research found that teachers seemed to focus more on the big ideas of mathematics rather than just following the textbooks. Teachers were more concerned with improving students' understanding of mathematics, and they concentrated on mathematical processes and problem solving rather than on basic skills.

Loucks-Horsley et al. (1998) found professional development initiatives that are created with the reform process in mind have distinctive characteristics: (a) there is an ongoing observation and evaluation of the concerns, questions, and needs of teachers with a focus on interventions and support on what is learned; and (b) attention is paid to implementation for several years for teachers to progress from an early focus on management to a later focus on student achievement.

Ongoing evaluation is another important component of professional development. Guskey (2002) declared that many consider evaluation to be more costly and time-consuming than it is worth. It diverts attention away from more important activities such as planning, implementation, and follow-up. However, in Guskey's research, evaluation had a strong presence. Guskey analyzed characteristics of effective professional development of more than a dozen research articles. The research included the publications of the American Federation of Teachers, Association for Supervision and Curriculum Development, National Staff Development Council, and the United States Department of Education and other educational publications. In the research, Guskey found a repeated emphasis on evaluation even though there has been little attention paid to its importance.

According to Guskey (2002), there are five levels of evaluation to improving schools' professional development program. The five levels include (a) participants' responses, (b) learning that occurred, (c) organizational support and change, (d) use of new knowledge and skills, and (e) student achievement or learning outcomes. Guskey and Sparks (1991) stated that evaluation should begin during planning and continue throughout all phases of program implementation and should collect evidence on measures that are meaningful to the stakeholders.

Guskey continued to state that professional development should include procedures for evaluation that measure its ultimate goal: improvements in student learning outcomes.

With the call for reform that promotes improved student learning outcomes, many efforts have been initiated. Most of these initiatives have concentrated on the creation of new curricula, others on professional development for teachers, and some on both. Still other initiatives concentrated on the use of technology in mathematics instruction (Edwards, 1994).

Math Initiatives

With the push and urgency of NCLB, many school districts in the United States began to evaluate performance standards and accountability following the publication of *A Nation at Risk*. *No Child Left Behind* initiated the term “scientifically-based research” into schools and reiterated the significance of accountability. In response, state boards focused on student achievement, while many individual programs looked at the relationship between the curriculum, professional development, and student performance (Pulliam & Van Patten, 2007).

Connected Mathematics Project

With accountability of student achievement and high stakes-testing significant issues, many states like Louisiana have implemented new mathematics initiatives. In Louisiana, educators have introduced new programs with differing strategies. These new programs propose to produce a greater improvement in student achievement when compared to traditional curricula. Louisiana’s state standards were revised to reflect more critical thinking and application objectives. In response, Connected Mathematics Project (CMP) was developed. It is a National Science Foundation (NSF) funded project created for middle school students that is

standards-based and problem-centered. The mathematics curriculum program begins in the sixth grade, phased into the seventh grade the next year, and the eighth grade the following year. Structured around the concepts of the NCTM Standards, CMP is devoted to the development of students' knowledge and understanding of mathematics that is rich in connections with real-world applications and with other mathematical concepts (Cain, 2002).

Intense professional development emerged to train teachers to meet the challenge of Louisiana's accountability measures and the implementation of the CMP. Teachers attend monthly inservices and receive weekly classroom assistance with instruction from a lead teacher, mentor, or coach. They receive instructional support provided by the lead teacher. This support is believed to be critical to the program's success and necessary to the implementation of standards-based reform mathematics. The teacher becomes both a student and a teacher of mathematics so that he or she is able to experience each problem the same way the student does (Cain, 2002).

CMP consists of 24 related units, each unit covering one major concept and its related topic in depth. Students use a hands-on, problem-solving methodology. They use critical thinking skills, collect data, solve real-life problems, and discover patterns and relationships in mathematics in collaborative groups. Each day the students work to solve a different but related problem. They work to develop their strategies for solving these problems. Concrete materials (manipulatives) are used so the students see the "big idea." The teacher has a major role to direct the students through their own discovery of a concept or pattern. To foster their comprehension as well as their retention of mathematical ideas, students discuss the problems, and explain their techniques of solving them (Cain, 2002).

The initial results showed an improvement in mathematics test scores. Using the average of the Iowa Test of Basic Skills (ITBS) results for the school year 1998-1999, sixth-grade students in CMP schools scored 16% higher than students in non-CMP schools. Seventh-grade students in CMP schools scored 9% higher than non-CMP schools. At the sixth-grade level, the average CMP total mathematics percentage score was 10% higher than the parish average, 7% higher at the seventh-grade level, and 16% higher than the state average ITBS score at both levels (Cain, 2002).

A comparison of sixth-grade students using the same six CMP schools in 1999-2000 school year showed mathematics scores to be 10% higher than the average sixth-grade mathematics total percentages of non-CMP schools and 5% higher than the parish average. For seventh-grade students, comparison of the same four CMP schools showed the ITBS scores to be 10% higher in mathematics than the seventh-grade students in non-CMP schools in the parish (Cain, 2002).

Not only in Louisiana but around the country, CMP has proven successful. In Texas, where the program was implemented in 22 sites, results of an evaluation showed an increase in student achievement from 9% to 19% improvement in some districts. In a more comprehensive study using the Iowa Test of Basic Skills (ITBS), test scores of 2,500 sixth-, seventh-, and eighth-grade students from urban, suburban, and rural communities were compared to scores of comparable students in non-CMP mathematics classrooms. The results of the study showed a significant difference in the scores of the CMP and non-CMP students in the eighth grade, with the CMP students advancing an average of 1.5 grade levels in mathematics from the fall to spring testing. There was less difference in the sixth- and seventh-grade students' scores. This was attributed to the fact that the curriculum was newer to these students (Cain, 2002).

Students also took the Balanced Assessment Test to assess their mathematical performance on open-response items demanded by new reform mathematics initiatives. Again, CMP students outperformed non-CMP students on this test. CMP students' growth was twice as much as non-CMP students from fall to spring testing at all three grade levels (Cain, 2002).

Middle Grades Mathematics Renaissance

The Middle Grades Mathematics Renaissance is a component of the California Alliance for Mathematics and Science, a National Science Foundation, and a funded state systemic initiative. The Mathematics Renaissance was created to help schools reform their mathematics program so that all students become proficient in mathematics. The Renaissance was designed to help middle schools respond to reform efforts through the use of professional development. Many students with diverse backgrounds who were typically underrepresented in mathematics were reached (Acquarelli & Mumme, 1996).

Renaissance's first step was to enroll selected schools throughout the state of California. The first step was based on the idea that as the program progresses, more schools want to get on board. This approach was based on the concept that systemic reform begins with a small number of schools and slowly increases to include more and more schools until the majority of other schools will follow (Acquarelli & Mumme, 1996).

Results of the study showed that strategies of the initiative were working with students, teachers, and parents. Evidence demonstrated that students from Renaissance classrooms outperformed those from other schools that were not participating in the program. Teachers, administrators, and parents commented that students' attitudes toward mathematics changed significantly. In mathematics class, students attempted more complex problem-solving tasks,

improved in their ability to express their mathematical thinking in writing, and the girls began showing more interest in mathematics (Acquarelli & Mumme, 1996).

The teachers worked to institute the NCTM Standards and 3 years into the 5-year plan, Renaissance's impact on teachers has been impressive. More than 1,000 mathematics teachers statewide regularly used cooperative learning, encouraged students to use concrete materials to investigate their hypotheses and solutions to problems, and guided students in expressing their solutions in writing and their use of calculators (Acquarelli & Mumme, 1996).

Teacher training was a major component to Middle Grades Mathematics Renaissance Project. If students are to become mathematically strong, all mathematics teachers must be prepared to teach in ways to reach this vision; therefore, preparation would begin with professional development (Acquarelli & Mumme, 1996).

The goal of teacher training was to develop a professional learning community where teachers interact through professional dialogue about the teaching and learning process, where pedagogy of professional development is harmonious with the pedagogy in the classroom, and with professional development that is grounded in classroom practice. Teachers were instructed on how to teach with the replacement units that were state-of-the-art. Teachers used the units in their classroom and then reported back to their cluster leader (Acquarelli & Mumme, 1996).

As part of the program, teachers participate in 8 to 12 professional development sessions during the school year, along with summer sessions. Ten full-time regional directors form statewide teams. Each regional director is responsible for seven groups or clusters with each cluster composed of five schools. In all, the project included 70 clusters, 350 schools, and 1,800 teachers with more than 250,000 students involved (Acquarelli & Mumme, 1996).

Middle Grades Mathematics Renaissance brought about changes such as (a) students actively engaged in complex, open-ended problems; (b) teachers with a renewed interest and excitement in teaching and classroom research; and (c) parents witnessing students' success in mathematics (Acquarelli & Mumme, 1996).

Accelerating Achievement in Math and Science in Urban Schools

Accelerating Achievement in Math and Science in Urban Schools (AAMSUS) project began in 2004 and was funded by Javits Education. The goal of the program was to incorporate 100 students in Grade 4 from each of the Ohio cities of Toledo and Dayton. A goal of the program was to use rigorous strategies to increase math achievement. The program's objectives included changing students' attitudes and stimulating interest in math and science and to support the idea that math and science is present in everyday life and that it is present and intriguing in our environment (Coleman & Southern, 2006).

AAMSUS focused on the math and science in urban schools with high-minority, economically disadvantaged students who perform below the national average in mathematics and science. Teachers' professional development included extensive training for them to identify students who had potential in mathematics and science. They were trained to identify students who possessed specific strengths in the curricular areas of mathematics and science. Students were nominated by teacher recommendation, standardized test scores, and state-developed accountability assessments. The program provided enrichment and accelerative experiences that occurred in-class, on Saturdays, and 2 weeks during the summer at the University of Toledo and Miami University (Coleman & Southern, 2006).

In year 1, the intent of AAMSUS was to determine base-line data and to promote the idea that mathematics and science is present in the environment in intriguing and interesting ways. And, in the next 4 years, the plan would include more accelerative math and science opportunities as well as preparation for high-stakes tests (Coleman & Southern, 2006).

Results from the study were mixed. Many students showed strong evidence of academic achievement on normed-tests while others did not. Some had difficulties in reading, which brought about problems in mathematics and science. Teachers reported that the participating students behaved differently in school. In fact, behavior improved and homework was finished more promptly. The students' conversations were more excited about the curriculum. They were more engaged in class, asked more questions, and were more independent in their learning (Coleman & Southern, 2006).

Multiple mathematics initiatives have originated in the last few years. Many are based on teachers' professional development. Hiebert (1999) confessed that through professional development, it is possible to create curriculum and pedagogy that help students increase their mathematics achievement; however, the question is whether these goals are valued enough to invest in professional development opportunities for teachers to learn to teach in ways required.

Alabama Math, Science, and Technology Initiative

History of AMSTI

The Alabama Math, Science, and Technology Initiative (AMSTI) was created to meet the serious need to improve math and science instruction in schools across the state of Alabama. In 1999, the Alabama State Superintendent of Education and the Deputy State Superintendent of Education initiated a mathematics and science reform effort. AMSTI, a professional

development initiative, was to launch a systemic reform effort for mathematics and science in Alabama (Alabama State Department of Education, 2009).

In January 2000, a blue-ribbon committee was composed by the Alabama State Department of Education. The committee members included leading mathematics and science teachers, administrators from Grade K-12, university faculty and administrators, along with members from business and industry including representatives of the National Aeronautics and Space Administration (NASA). The committee (a) completed an extensive review of literature; (b) examined state, national, and international assessment data; (c) investigated programs and initiatives already implemented in Alabama and nationally; (d) looked at the needs of business and industry; (e) reviewed national standards; (f) reviewed the Alabama Course of Study and certification requirements; and (g) mailed a needs assessment survey to Alabama teachers. A genuine effort was made to ensure AMSTI was researched-based and incorporated best teaching practices (Alabama State Department of Education, 2009).

The administrators of AMSTI developed a strong working relationship with several programs already established in Alabama. GLOBE--an acronym for Global Observations to Benefit the Environment--is included as a part of the AMSTI training. GLOBE, an international science research program, inspires students to perform real environmental research and enter their data in databases that are tied to scientists around the world. The Alabama Science in Motion (ASIM) Program, established well before AMSTI's inception, is the high school science component of AMSTI. In conjunction with mathematics and science, reading and writing are also a part of AMSTI's instruction. Reading strategies conducted through the Alabama Reading Initiative (ARI) are included in instruction received by AMSTI schools. Many material modules include relevant reading materials that incorporate math and reading strategies. Writing is also

addressed through AMSTI math and science journal activities (Alabama State Department of Education, 2009).

The committee worked for a year studying and researching best practices. It was decided to model the AMSTI program partially after the Hands-on Activity Science Program (HASP) that has received national recognition. HASP uses tested modules that are based on research, inquiry-based teaching strategies, and authentic assessment. Initial funding for HASP was from a grant by the National Science Foundation. The grant was issued to assist an industry-school partnership to improve science education in the North Alabama area, especially Huntsville, Alabama, where HASP has been based at the University of Alabama in Huntsville, since 1990 (Alabama State Department of Education, 2009).

The committee continued to work to determine recommendations for the initiative. In December 2000, the State Board of Education unanimously adopted the committee's recommendations and officially named the initiative Alabama Math, Science, and Technology Initiative (AMSTI). A committee was appointed to help in the process of turning the recommendations into a viable program. The plan called for establishing support sites across the state called AMSTI sites. Eleven geographical Regional Inservice Centers would be established to implement the state's initiative. Each AMSTI site would function under the direction of the Alabama State Department of Education (Alabama State Department of Education, 2009).

The State Department of Education appointed committees; one committee selected the math curricula and materials for each grade. Modules were structured around curriculum from the United States Department of Education's Expert Panel on Exemplary and Promising Mathematics Programs. Another committee selected the science curricula and materials that would be supplied to teachers during the first year of their training. Modules were developed

with research-based materials and supported by the National Science Foundation (NSF). The curricula are highly aligned with state and national standards (Alabama State Department of Education, 2009).

The Alabama Department of Education involved over 400 individuals for a 3-year period to select the curriculum, its resources, and develop implementation guides for the Summer Institute trainers. Once the modules and implementation guides were developed, trainers were hired to conduct presenter certification services. The goal was to focus on training a group of individuals capable of teaching the modules at AMSTI Summer Institutes. All of this work was done to ensure that all teachers are provided high-quality, standardized, professional development focused on state standards (Alabama State Department of Education, 2009).

As training of presenters continued, funding became a critical issue. The State Department of Education and the Alabama Mathematics, Science, and Technology Education Coalition (AMSTEC) attempted to obtain funding by several means. A number of partnership meetings were held with higher education entities, business, and industry (Alabama State Department of Education, 2009).

AMSTEC was successful in getting much of AMSTI's funding. AMSTEC was incorporated in 1998 as a non-profit organization. It was created out of a National Aeronautics and Space Administration (NASA) funded Linking Leaders Program. AMSTEC is composed of leaders from business, education, government, and policymakers who endorse systemic K-20 mathematics, science, and technology education reform. AMSTEC has grown to a statewide alliance of integrated stakeholders in mathematics, science, and technology education. Its mission is to improve mathematics, science, and technology education in Alabama through the

means of communication with and among education, business, and public policy organizations (Alabama State Department of Education, 2009).

Funding for the first AMSTI site was the result of work from Congressman Bud Cramer. In the spring of 2002, AMSTI received a \$3 million grant from NASA. Frank Owens and Jim Pruitt at Marshall Space Flight Center were instrumental in the grant acquisition. The University of Alabama (UAH) in Huntsville was chosen to be the pilot Math, Science, and Technology Education Resource (MASTER) site. MASTER sites are responsible for supplying the professional development, the math and science modules, and the materials refurbishing center along with the math and science specialists for each of the AMSTI in-service district areas (Alabama State Department of Education, 2009).

In 2002, UAH conducted the first Summer Institute. Twenty schools attended the Summer Institute on the UAH campus and were designated the first official AMSTI schools. In order to apply to the AMSTI MASTER site, each school had to have at least 80% of their math, science, and technology teachers willing to participate in Summer Institute. External evaluators closely monitored the activities of the Summer Institute and subsequent implementation of the math and science modules and practices in the classrooms (Alabama State Department of Education, 2009).

Further expansion continued through the second semester of the 2003-2004 school year. The University of North Alabama (UNA) received a small grant and began setting up its materials' center and training teacher leaders. The University of South Alabama (USA) was awarded an AMSTI site. Funding was provided by the U.S. Department of Education's Math and Science Partnership Grant, which is managed by the Alabama State Department of Education.

During the summer of 2004, USA conducted its first Summer Institute with approximately 350 teachers and administrators attending (Alabama State Department of Education, 2009).

Evaluation of AMSTI

The first evaluation results of student achievement were measured by standardized test scores. Data collected from the *Stanford Achievement Test Tenth Edition (SAT 10)*, the *Alabama Direct Assessment of Writing (ADAW)*, and the *Alabama High School Graduation Exam (AHSGE)* were used in the comparison. Student achievement data were taken from the *Impact of AMSTI on Student Performance on Standardized Tests--a report developed for the Alabama Department of Education by the Institute for Communication and Information Research at the University of Alabama*. The external evaluator analyzed the data and compared the performance of AMSTI schools and non-AMSTI schools in the 16 school systems where AMSTI was implemented beginning July 2002 through May 2004. The analysis compared 41 AMSTI schools to a control group of 170 non-AMSTI schools with similar demographics. The study showed “statistically significant differences” between AMSTI schools and the non-AMSTI schools on several comparisons. According to the evaluators, marked improvements were found using multiple assessments (Alabama State Department of Education, 2009).

In 2005, data collected by the external evaluators indicated significant gains in student performance on the standardized tests in the schools involved in AMSTI. The study compared 75 AMSTI schools from 20 school systems to a control group of 265 non-AMSTI schools. According to the evaluation report, AMSTI schools scored higher in mathematics and science than the schools in the control group after 1 year of implementation (Alabama State Department of Education, 2009).

In 2006, the Office of Community Affairs at the University of Alabama became the external evaluator. Twenty-seven school systems where AMSTI was implemented during the period from July 2002 and May 2006 were included in the evaluation. The report compared 107 AMSTI schools who adopted AMSTI in 2005 to a control group of 348 non-AMSTI schools with similar demographics. According to the Office of Community Affairs, the study validates that AMSTI is making a real difference in the academic performance of students in math and science instruction. On every standardized test given by the State Department of Education, AMSTI schools outperformed, often dramatically, non-AMSTI schools. (Alabama State Department of Education, 2009).

In 2007, the external evaluators, the Office of Community Affairs at the University of Alabama, analyzed the academic performance of the standardized test scores of 2007. Performance of all AMSTI schools and non-AMSTI schools in the 55 school systems where AMSTI was implemented during the 5-year period from July 2002 to May 2007 were used in the examination. Data of 90 AMSTI schools who adopted the program in 2006 was compared to a control group of 494 non-AMSTI schools with similar demographics. Again, marked improvement was found using multiple assessments. There was a dramatic decrease in the percentages of students who scored at Level 1 (below standards) and Level 2 (approaching standards) on the Alabama Reading and Mathematics Tests (ARMT). In addition, there were other academic areas that showed improvement. Data indicated an improvement in reading and an improvement in the scores of the *ADAW* administered to students in Grade 5 and Grade 7 (Alabama State Department of Education, 2009).

According to the analysis of 2007 *SAT 10* test data, students in AMSTI schools outperformed students in non-AMSTI schools by up to 9.33 mean percentile rank points and 9.75

points in science. On the ARMT, up to 14.47% more students scored at Level III or above proficiency levels (Level IV) in math and science compared to non-AMSTI schools. Also, AMSTI schools outperformed the control schools by up to 7.47 percentile rank points in reading as measured by the *SAT 10* and 12.83 percentile rank points in the *ADAW*. In addition to the 2007 test data evaluations, the fifth major study validated evaluations from 2003, 2004, 2005, and 2006 (Alabama State Department of Education, 2009).

The data showed the program improved the learning of lower performance students in comparison with the traditional teaching and learning methodology. AMSTI consistently raised the schools' minimum *SAT 10* percentile ranks. The data showed a statistical significance in improvement of scores among students from AMSTI schools when compared to non-AMSTI students. The evaluation also revealed improvement in teachers' cooperation and overall student participation. Coincidentally, the study also showed that in most AMSTI schools discipline improved as students were more involved in their learning process (Alabama State Department of Education, 2009).

In school year 2005-2006, AMSTI became an item in the state budget and progressed from a grant supported initiative to a legislative supported one. By 2006-2007, statewide reform grew from having only three areas of the state to an initiative that encompassed eight areas of the state. The new AMSTI Master sites included the University of Montevallo, Troy University, The University of Alabama, Wallace Community College-Selma partnering with Alabama State University, and Jacksonville State University. Funding permitting, future plans include expanding into all 11 in-service center regions enabling AMSTI to serve all the students in Alabama. Since 2002 over 600 schools statewide have become AMSTI schools. Daily, over

350,000 students receive instruction by AMSTI certified teachers (Alabama State Department of Education, 2009).

Committee Recommendations

The AMSTI Committee made several recommendations in the subject areas of instruction, curriculum, assessment, professional development, and resources. Math and science instruction is to concentrate on student understanding through the development of concepts at all grade levels. Instructional strategies should address the needs of all the students by using purposeful, hands-on, inquiry-based instruction; relevant, real-life experiences while being engaged through exploration, reasoning, and problem solving; effective questioning; appropriate use of knowledge; relevant discussions of mathematical and scientific ideas; mastery and use of appropriate dialogue with mathematical and scientific ideas; and integration of appropriate technology (Alabama State Department of Education, 2009).

Curriculum recommendations included the call for the reduction of the breadth of math and science content with an increase in depth of student understanding. Also, the committee recommended the development and implementation of courses of study for mathematics and science that outlined what students should know at each grade-level with standards parallel to the National Council of Teachers of Mathematics (NCTM), the National Research Council (NRC), and the International Society for Technology in Education (ISTE) standards; student achievement targets identified for mathematics and science curriculum in Grades K-8; and the creation of strategies and opportunities for alternative learning that support intervention and remediation at each grade level. Mathematics curriculum was also selected to be reformed to meet these recommendations (Alabama State Department of Education, 2009).

Recommendations on assessment included the implementation of a student assessment plan that is a critical part of classroom instruction and structured to mirror the National Council of Teachers of Mathematics (NCTM) and the National Research Council (NRC) standards. Also, these created assessment plans should include different forms of assessment at the classroom level as well as statewide level (Alabama State Department of Education, 2009).

Professional development recommendations mandated the provisions for mathematics teachers, science teachers, and administrators that is appropriate, ongoing, effective, and extensive. Appropriate professional development for teachers is to include content and pedagogical knowledge; knowledge of state curricula requirements; correct choice and use of curriculum, materials, and resources; research-based, best teaching practices and strategies; a variety of assessment strategies; strategies for working with students performing below grade-level; and the integration of technology in planning for instruction. The AMSTI committee recommendations also suggested the alignment of pre-service education programs with the mathematics standards endorsed by the NCTM and science standards promoted by the ISTE (Alabama State Department of Education, 2009).

Resource recommendations included having mathematics and science teacher-leaders for appropriate grade-levels at each school, each school should have a full-time technology specialist, adequate space and provisions for mathematics and science teaching, a website available for mathematics and science resources or links, and maintain well-equipped mathematics and science classrooms that make appropriate supplies, materials, and technology easily accessible for quality instruction. Manipulatives, calculators, activity kits, trade books, literature, science consumables and non-consumables, and other materials were recommended to be provided for each classroom. Also, the Mathematics, Science, and Technology Resource

(MASTER) sites statewide should support local schools and school systems in executing the recommendations the committee suggested (Alabama State Department of Education, 2009).

Further Research on AMSTI

In addition to the Alabama State Department of Education reporting results of AMSTI, there have been a few dissertations that examined the different aspects of the Initiative. In 2008, Janis Stewart completed a study on AMSTI. The study was reflected as a dissertation at Alabama State University, Montgomery. Stewart's mixed-method designed study examined the perceptions of teachers and administrators in the original AMSTI schools to determine the effects of participation in AMSTI on their schools. The study also examined the achievement of students in the 16 original AMSTI schools to determine whether participation in AMSTI had improved the test scores on the *Stanford Achievement Test Tenth Edition (SAT 10)*. Students' standardized achievement data in the 16 original AMSTI elementary and middle schools were compared with the 16 demographically similar, non-AMSTI schools. Analysis of the data indicated that there was no statistically significant difference in the scores between AMSTI and non-AMSTI schools (Stewart, 2008).

In another study in 2006, Carolyn Pistorius also completed a study on AMSTI. The study was reflected as a dissertation at The University of Alabama, Tuscaloosa. It was designed to determine the impact AMSTI professional development and other attributes the AMSTI program had on teachers' perceptions of AMSTI as well as their implementation of the program itself. The teachers were asked to evaluate the effectiveness of the AMSTI program and identify its strengths and limitations. Teachers were also asked to determine the program's usefulness as

well as the amount of time they actually used the science modules included in the program (Pistorius, 2006).

Pistorius' study included 85 middle school teachers from three school districts who had participated in at least one AMSTI Summer Institute by the end of the 2005 summer. All the participants taught science, and all the schools where the participants taught ranged from rural to urban to suburban. The teachers used a range of resources of their choice to teach their science students, but all had been trained on the implementation of the AMSTI modules, GLOBE protocol, and science notebooks (Pistorius, 2006).

Data were collected through multiple methods including a survey, interviews, and classroom observations. Analyses of the data showed that teachers had more confidence teaching the lessons from the modules after receiving two professional development sessions. Also, the teachers tended to have a positive attitude about using the science modules as well as teaching science in general (Pistorius, 2006).

Analyses of the data also showed the strengths of the AMSTI program included the allocation of materials, inquiry based hands-on lessons, professional development provided, support specialist on hand, and the positive effects on the students. Numerous limitations included management and storage of materials, struggle to get the lessons prepared, fitting everything into the time allocated, the need for more technology to be embedded into the lessons, and better communication with AMSTI and the materials supplier companies (Pistorius, 2006).

Another AMSTI study was completed in 2007 by Sherry Kelley. As a dissertation, Kelley investigated teachers' perceptions of AMSTI and its impact on their instructional practices. Two data sources, the AMSTI Mathematics Questionnaire and an interview protocol, were used. Open-ended narrative questions investigated the impact the number of years of teaching

experience, grade level taught, and highest degree attained had on elementary teachers' perceptions of the mathematics component of AMSTI. Three focus group interviews with teachers in Grades K-5 were used to collect more in-depth information about teachers' perception of the AMSTI professional development and its influence on their instructional practices in mathematics (Kelley, 2007).

The results of Kelley's study indicated that AMSTI training appeared to have had an impact on instructional practices of the participating teachers. One of the main impacts of AMSTI was the changes that occurred in teaching practices. Teachers stated that as a result of participation in AMSTI they used more hands-on learning, problem solving with questioning and discussion, and more cooperative learning. And, after AMSTI training, teachers tended to use constructivist practices more in-line with the NCTM (Kelley, 2007).

Another study was completed in 2007 by Mary Harris. The central theme of Harris' dissertation involved the curricula adaptations teachers made in order to teach science. The study explored the idea of how exemplary science teachers teach science, given the curricular mandates that limit science instructional time (Harris, 2007).

Harris completed case studies with two exemplary elementary science teachers. The purpose of the study was to explore the teachers' instructional strategies and methods and identify how the teachers adapted the curriculum in order to meet the mandates that marginalized science instructional time (Harris, 2007).

Harris (2007) addressed the subject of mandates and school programs that included the ARI, DIBELS, HASP, and AMSTI. Harris stated that HASP had been incorporated into AMSTI. In districts where HASP materials were funded by a National Science Foundation grant, many of the HASP science modules had been enfolded into AMSTI.

The results of the analysis of data showed that exemplary science teachers use AMSTI strategies after receiving AMSTI professional development. In fact, Harris noted that AMSTI is appealing to districts desiring science materials because the initiative funds the use of modules and their refurbishment (Harris, 2007).

Summary

Mathematics education has been the topic of much debate for many decades. It seems controversy is derived from the dissatisfaction about what mathematics is being taught, the way it is being taught and assessed as well as the support teachers receive while trying to accomplish ever-changing goals and expectations. In reaction to the dissatisfaction in mathematics education a movement toward reform emerged.

This reaction led to the development of committees and publishing of documents highlighting important mathematical pedagogy, curriculum, and assessment practices. Along with publications such as *A Nation at Risk*, *Educating Americans for the Twenty-First Century*, and *Goals 2000*, the National Council of Teachers of Mathematics (NCTM) formed and began creating documents supporting the vision of reform in the teaching, curriculum, and assessment practices of teaching mathematics.

Supporting the need for mathematics reform and the importance of developing educational excellence in mathematics were the results of the Third International Mathematics and Science Study and Trends in International Mathematics and Science Study (TIMSS; IES National Center for Educational Statistics). The United States did not fare well, scoring in the middle ranking falling behind Asian countries. The TIMSS report suggested that American

curricula and teachers' mathematical abilities were core themes to blame for the lackluster performance of the U.S. students.

Clearly, it was time to make significant changes. The state of mathematics education and research in the U.S. reflected the conflict between reform and the new age of accountability. Initiated in 2001, the *No Child Left Behind* (NCLB) act was the result of 15 years of standards-based reform discussion. NCLB was designed to improve the academic performance of all students in kindergarten through high school. It called for greater responsibility and accountability for student learning from teachers and schools. If this vision of improving mathematics education is accomplished, educational reform is necessary, and professional development of teachers is deemed central to this reform effort in mathematics (Loucks-Horsley et al., 2003).

Research on professional development shows the need to assist teachers in their understanding of learners and learning, subject matter they teach, and pedagogy. Darling-Hammond (1998) pointed out that the expertise of the teacher is one of the most critical factors in student achievement. When professional development programs create an environment that helps and supports teacher learning and supports teachers in their challenges to integrate new concepts and instructional strategies into their ongoing programs, then teachers can begin to teach in ways supported by reform (Guskey & Huberman, 1995).

With the call for reform that promotes improved learning outcomes, efforts have been initiated. School districts, local and throughout the U.S., began to evaluate performance and accountability standards. Many of these initiatives have concentrated on the creation of new curricula, others on professional development for teachers, and some on both.

Efforts by the Alabama State Department of Education created the Alabama Math, Science, and Technology Initiative (AMSTI). Through formation of committees in January 2000, AMSTI was created. In the summer of 2002, the first professional development session, referred to as Summer Institute, was conducted with representatives from 20 schools attending. Since 2002, further expansion has continued to occur with over 600 schools statewide becoming AMSTI schools. Daily, over 350,000 Alabama students receive instruction by AMSTI certified teachers (Alabama State Department of Education, 2009).

Representatives of AMSTI make the claim that test data from the *ARMT*, *SAT 10*, the *ADAW*, and *ASHGE* showed “significant difference” in students’ scores in AMSTI schools when compared to students in non-AMSTI schools. However, there are no published results of studies in professional education journals or other outside research supporting their claim other than graduate students’ dissertations. Therefore, investigating AMSTI’s claim of being highly successful in improving student achievement in mathematics when results are collected and analyzed by sources other than AMSTI’s own external evaluators is important.

CHAPTER 3

METHODOLOGY

The purpose of this study was to determine if there was a difference in student achievement in mathematics between those students in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and those students in non-AMSTI classrooms. In addition, this study sought to determine the perceptions of teachers who had been trained in AMSTI strategies and used them in their classrooms along with the perceptions of the teachers who had not been trained.

Research Questions

1. What are the differences between *Stanford Achievement Test 10 (SAT 10)* mathematics scores of fourth- and fifth-grade students who have been instructed in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and those in non-AMSTI classrooms?
2. What are the differences between *Alabama Reading and Mathematics Test (ARMT)* mathematics scores of fourth- and fifth-grade students who have been instructed in AMSTI classrooms and those in non-AMSTI classrooms?
3. What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have received AMSTI training?
4. What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have not received AMSTI training?

Permission for the Study

Prior to the study, permission was obtained to conduct the study from and granted by the Institutional Review Board (IRB) for the Protection of Human Subjects (Appendix B). Teachers included in the study were assured their participation was voluntary and results would remain confidential. In addition, permission to conduct the study was received from the superintendent of the participating schools.

Setting and Population

Schools

This study was conducted with elementary students in Grades 4 and Grades 5 as well as their teachers. By using Grade 4 and Grade 5 students, a comparison was made with *SAT 10* and *ARMT* scores for school years 2008-2009 and 2009-2010. This was a comparison that could not be made with students in Grade 3 and lower in this school system because standardized testing began in Grade 3. Students in Grade 6 were not included because they were located in middle school instead of elementary school, which involved different issues.

The students attended four public schools in the same school district located in north central Alabama. The selection of the participating schools was based on demographic homogeneity and whether or not they were classified as AMSTI schools. Two schools were AMSTI schools where teachers attended training in AMSTI methods and taught AMSTI instructional strategies in mathematics while the other two were non-AMSTI schools.

All four schools had comparable demographics. Many of the students were being reared in single-parent homes. This limited the amount of time for parental involvement in the

classrooms; however, some parents and community members volunteered in the VIPS (Volunteers in Public Schools) program.

All four schools were Title I schools where funds were received from state and federal agencies to support reading instruction for low-achieving students. All schools had inclusion classes for students with special needs. According to individual needs, students received services in classrooms with their peers or in a resource room. The Alabama Reading Initiative held a strong presence in all four schools. Students maintained adequate yearly progress (AYP) on state mandated standardized tests and all schools were part of K-12 campuses (Alabama State Department of Education, 2008).

The first AMSTI school was Grace Intermediate (pseudonym). Grace Intermediate had been an AMSTI school since 2006. It was a rural school, Grades 3 through Grades 5, with an enrollment of 213 students in fourth and fifth grades. Approximately 92% of the fourth-grade students were Caucasian and 7% Hispanic, with 60% of the students participating in the free and reduced nutritional program. Of the fifth-grade students, 94% were Caucasian and about 4% were Hispanic. More than 62% of the students participated in the free or reduced nutritional program. Four teachers taught 115 fourth-grade students while 98 fifth-grade students were taught in a departmentalized structure with one teacher responsible for teaching mathematics (Alabama State Department of Education, 2009).

Haven Elementary (pseudonym), the second AMSTI school, became involved in AMSTI in 2008. It was a rural K-5 school. Three teachers taught 76 students in fourth grade and three teachers instructed 66 students in fifth grade. About 95% of the fourth-grade students were Caucasian and 1% were Hispanic, with more than 50% of the students participating in the free or reduced nutritional program. In fifth grade, approximately 91% were Caucasian and 6%

Hispanic, with 61% who participated in the free and reduced lunch program (Alabama State Department of Education, 2009).

The two comparable non-AMSTI schools were Vincent and Claremont Elementary (pseudonyms). Vincent was a rural K-5 school with 95 students in fourth grade and 80 students in the fifth grade. Mathematics was taught by four teachers in fourth grade in self-contained classrooms and one teacher in fifth grade in a departmentalized setting. Of the fourth-grade students, approximately 91% were Caucasian and 8% are Hispanic, and more than 68% were eligible for the free or reduced lunch program. There were 80 students in the fifth grade with 99% Caucasian and 1% Hispanic. Approximately 60% of the students participated in the free and reduced lunch program (Alabama State Department of Education, 2009).

Claremont was also a rural K-5 school with 59 students in fourth grade and 69 students in fifth grade. Three teachers in the fourth grade and four teachers in the fifth grade were responsible for the mathematics instruction each day. Approximately 98% of the fourth-grade students were Caucasian and 2% Hispanic. About 53% of the students in fourth grade participated in the free or reduced nutritional program. Of the fifth-grade students, 100% were Caucasian, with 48% of the students participating in the free and reduced lunch program (Alabama State Department of Education, 2009). Table 1 displays the demographic data for the four schools. Table 2 includes the demographics for the participating AMSTI teachers, and Table 3 displays the demographic data for the non-AMSTI participating teachers.

Table 1

School Demographics

School	Race		% Free and reduced lunch	N of teachers	N of students
	% Caucasian	% Hispanic			
AMSTI: Grace Elementary					
Fourth grade	92	7	60	4	115
Fifth grade	94	4	62	1	98
AMSTI: Haven Elementary					
Fourth Grade	95	1	50	3	76
Fifth Grade	91	6	61	4	66
Non-AMSTI: Vincent Elementary					
Fourth grade	91	8	68	4	95
Fifth grade	99	1	60	1	80
Non-AMSTI: Claremont Elementary					
Fourth grade	98	2	53	3	59
Fifth grade	100	0	48	4	69

Table 2

AMSTI Participating Teachers' Demographics

Name	AMSTI Year I		AMSTI Year II		Self-contained	Departmentalized	Years teaching/ years teaching this grade	Highest degree earned
	Grade level	Trained	Grade trained in	Trained				
Mr. K	5	Yes	3	Yes	5	X	2/1	BS
Ms. L	4	Yes	3	Yes	4		35/14	AA
Ms. D	4	Yes	5	Yes	5		25/10	MS
Ms. S	4	Yes	4	Yes	4	X	9/2	MS
Ms. G	5	Yes	4	Yes	5		4/2	MS
Ms. S	5	Yes	4	Yes	5	X	20/19	MS
Ms. P	5	Yes	5	Yes	5	X	12/11	MS
Ms. A	5	Yes	5	Yes	5	X	8/8	MS
Ms. D	4	Yes	3	Yes	4	X	11/9	MS
Mr. L	4	Yes	4	Yes	4	X	5/5	BS
Ms. W	4	Yes	4	Yes	4	X	3/3	BS

Table 3

Non-AMSTI Participating Teachers' Demographics

Name	Grade level	Self-contained	Departmentalized	Years teaching/ years teaching this grade	Highest degree earned
Ms. K	4	X		6/6	MS
Ms. A	4	X		13/7	MS
Ms. J	4	X		16/8	MS
Ms. S	4	X		6/3	MS
Ms. S	4	X		14/12	AA
Mr. M	5		X	20/17	AA
Ms. L	5	X		7/5	BS
Mr. L	5	X		5/5	BS
Ms. B	5	X		13/12	MS
Ms. B	5	X		8/7	MS

Description of AMSTI Training

The AMSTI training process began with a commitment by at least 80% of a school's math, science, and technology teachers willing to attend two summer sessions of professional development called Summer Institute. Summer Institute, AMSTI's professional development module, was conducted for 2 weeks, 5 days a week from 8:00 A.M. until 3:30 P.M., for 2 consecutive summers. Math instruction was taught for 1 weeks and 1 week science was taught.

For each 1-week session, teacher participants were issued a large notebook along with curriculum developed into individual books. The curriculum was the *Investigation in Number, Data, and Space* by Scott-Foresman. Investigations was a K-5 curriculum with each grade level and skills to be taught organized into units of number, data analysis, and geometry. The curriculum was developed by TERC and partially funded by the National Science Foundation and was designed to encourage students to use problem-solving strategies, think creatively, and work effectively in a cooperative setting. Instruction was linked to the NCTM Principles and

Standards and correlation was made with skills taught with the State of Alabama Course of Study for Mathematics.

Each morning, class started with signing in and reporting to the grade specific classroom. Early morning activities included critical thinking skills typically using Venn diagrams and an open discussion and analysis of the data. Hands-on activities involved the teachers actively engaged with the skill and a full discussion of how the trainer used it in the classroom. Notes on the activities were recorded in a journal just as if the teachers were fifth-grade students.

Instruction varied. The trainer changed the activities in the classroom by rotating between teaching hands-on math activities, interacting with the students, and presenting PowerPoint presentations on topics such as learning styles and effective teaching practices. Often articles were read and discussed about current trends in mathematics. The class structure was designed to encourage student involvement through open discussion and participation along with a time for daily reflection.

With completion of Summer Institute, teacher participants were provided with resources needed to implement the mathematics component of AMSTI in their classrooms. Ready-to-use kits, *Investigations* curriculum, and manipulatives needed for hands-on activities with the students, were sent to the participants' classrooms. The math kits were kept in the classrooms because they did not have to be returned to the AMSTI Inservice Center for refurbishment.

Once teachers were trained in Summer Institute, they were expected to use the *Investigations* curriculum in their classrooms. Follow-up assistance was provided to the teachers by a designated Teacher Leader and an AMSTI Math Specialist. The Math Teacher Leader was a teacher chosen by each school's principal from the participating teachers in the AMSTI Summer Institute. The AMSTI Specialist was a teacher who worked from the AMSTI master site that

visited each school to assist both the Teacher Leader and the teachers with their incorporation of the AMSTI skills and strategies.

The Mathematics Teacher Leader had specific duties to assist the teachers in their transition to AMSTI instruction. The Teacher Leader acted as a liaison between the classroom teachers and the AMSTI Master Site. He or she notified the Master Site if there were any problems with the kits and materials. Also, the Teacher Leader was available to assist with planning, content knowledge, curriculum implementation, instructional strategies, and any other viable needs that arose in the AMSTI classrooms. In addition, the Teacher Leader was responsible for requesting assistance from the AMSTI Math Specialist.

Upon completion of Summer Institute Year 1 and Year 2 in mathematics, AMSTI teachers were considered trained in the entire *Investigations* curriculum and activities for their grade level. However, help was always near with the ongoing assistance from the Math Specialist.

Design of the Study

This study included data from the mathematics section on the spring 2009 and spring 2010 *SAT 10* and *ARMT* tests along with interviews with the teachers. The *SAT 10* and *ARMT* tests were standardized tests that were mandated by the State and given to elementary students in public schools statewide. These tests provided valid and reliable tools needed for objective measurement of achievement (Alabama State Board of Education Standardized Tests, 2005). Every teacher was trained to administer each test by a strict protocol. The researcher used the spring 2009 and spring 2010 test data for mathematics of the fourth- and fifth-grade students in the participating schools to determine whether there was a difference in mathematics

achievement in AMSTI schools and non-AMSTI schools based on the students' scaled scores on the *ARMT* and *SAT 10* mathematics data.

The interviews with the teachers took place at the participating schools after regular school hours and during the teachers' planning periods during the spring of 2010. Because this was structured on a voluntary basis, the researcher interviewed 11 AMSTI teachers and 10 non-AMSTI teachers from both fourth and fifth grades. Each interview session took approximately 30 to 40 minutes each. The interviews were tape recorded and transcribed. According to Gall, Gall, and Borg (2003) tape recording provides a verbal recording that can be studied much more thoroughly than data from interviewer notes and it speeds up the interviewing process. Data were collected from the transcribed audiotapes to determine trends in the perceptions of the teachers.

Data Sources

SAT 10

The *SAT 10* was a standardized test used to measure academic knowledge. The mathematics assessment section included the assessment of mathematics procedures and problem solving. This measurement instrument provided the valid and reliable tool needed for objective measurement of student achievement (Alabama State Board of Education Standardized Tests, 2005). Its primary purposes were to compare individual and group performance with the performance of the norming group, report relative strengths and weaknesses of individuals and special groups, and to provide data to study changes in performance over time (Alabama State Department of Education, 2008). The *SAT 10* provided reliable data to evaluate progress toward meeting the challenges and expectations of *No Child Left Behind* (Alabama State Board of Education Standardized Tests, 2005).

ARMT

The *ARMT*, the *Alabama Reading and Mathematics Test*, was first piloted statewide in 2004 for Grades 4, 6, and 8. In 2005, Grades 3, 5, and 7 joined in the statewide administration of the criterion-referenced test based on Alabama's academic content standards in reading and mathematics. The *ARMT* was a standards-based test that measured specific skills defined for each grade by the state of Alabama. The goal was for all students to score at or above the state standard (Alabama State Board of Education Standardized Tests, 2005).

Interviews with Teachers

The researcher's plan called for interviews to include at least four teachers from each participating school. The researcher was actually able to interview 11 teachers from the AMSTI schools and 10 teachers from the non-AMSTI schools. Two non-AMSTI teachers were unable to schedule the interview with the researcher, while one AMSTI teacher was on maternity leave.

The Interview Protocol (Appendix C) for AMSTI teachers was partially based on the design created by Kelley (2007), in a dissertation at The University of Alabama, and partially developed by the researcher along with a coordinated effort of professors at The University of Alabama (Appendix C; Kelley, 2007). In the AMSTI schools, 11 teachers represented fourth and fifth grades. Teachers in the non-AMSTI schools were asked to participate in interviews using the Interview Protocol for non-AMSTI Teachers. This protocol was developed by the researcher in conjunction with University of Alabama professors (Appendix D). In the non-AMSTI schools, 10 teachers represented fourth and fifth grades.

Once the 11 AMSTI teachers' and the 10 non-AMSTI teachers' interviews were transcribed, the researcher thoroughly read the information noting certain dominate categories.

Studying the categories of the data, and becoming aware of the patterns, important and repeated themes arose (Shank, 2006). Research Question 3 and Research Question 4 reflect the researcher's findings from the interviews.

Data Collection and Analysis

A mixed-methods design was used to address the research questions. Quantitative methodology was used to address Research Questions 1 and 2, and qualitative methodology was used to investigate Question 3 and Question 4.

Research Questions 1 and 2 examined the differences between standardized math test scores of fourth- and fifth-grade students who had been instructed in AMSTI classrooms and students in non-AMSTI classrooms. The *SAT 10* reports the students' scores in three separate mathematics scores: Total Mathematics, Mathematics Problem Solving, and Mathematics Procedures. For the purpose of this study, the total mathematics mean-scaled scores were used in the analysis because they represent the combination of mathematics problem solving and mathematics procedures. On the *ARMT* test, the students' scaled scores were used, also. To examine the relationship, the researcher used independent *t* tests.

Qualitative methods were used to examine Research Question 3 and Research Question 4. Research Question 3 addressed the perceptions of fourth- and fifth-grade teachers about AMSTI. Question 4 addressed the perceptions concerning AMSTI, AMSTI strategies, and professional development of the fourth- and fifth-grade teachers who had not received AMSTI training.

The interviews with the teachers were conducted in a classroom at each of the schools involved in the study. The researcher asked for permission to tape record the interviews and

reassured the participants of their anonymity. Bogdan and Biklen (1998) stated that permission must be given by the participants before tape recording the interviews. Also, participants want assurance that private information will not be revealed to others at their expense.

According to Gall et al. (2003), tape recording speeds up the interview process while providing a verbal recording that can be studied much more thoroughly than data from interviewer notes. More importantly, tape recorders reduce the tendency for interviewers to make an unconscious selection of data favoring their biases. In addition, qualitative methods such as interviews stimulate the participants to share their feelings, perceptions, and beliefs in a safe environment.

To insure accuracy, the researcher conducted electronic member checking with the interviewed teachers. According to Gall et al. (2003), member checking is a process where research participants are given the opportunity to determine the accuracy of their statements that were captured by the researcher with the intent to be used in a study.

The transcribed interviews of 11 individual, AMSTI teachers and 10 non-AMSTI teachers provided the qualitative data. Thematic analysis (Shank, 2006) was used. The researcher read through the interviews carefully, noting certain dominate categories of the data. After analyzing the data, patterns formed and different themes arose (Shank, 2006). The researcher used these dominate themes to discuss Research Question 3 and Research Question 4.

Researcher Positionality

The researcher is a fifth-grade teacher who has 14 years of experience teaching elementary students. For the last 5 years, she has worked in a departmental class structure where she has been responsible for teaching mathematics to approximately 100 students daily. The

researcher works in an inclusive classroom setting where students with special needs are accommodated in the classroom with their peers.

The elementary school in which the researcher works had an opportunity to become an AMSTI school; however, the faculty voted not to participate in the AMSTI training. The reason the faculty gave for not participating was because teachers in kindergarten through third grade had completed the Alabama Reading Initiative training the previous summer. They were still reeling from the changes that were occurring in their classrooms. Even though the researcher voted for the school to become an AMSTI school, 80% of the faculty did not vote for it; therefore, no faculty would receive training.

To be able to complete a study on AMSTI, the dissertation chairperson and researcher felt that she needed to learn more about AMSTI than she could read from the website. The researcher contacted the Alabama State Department of Education with her dilemma: How to become AMSTI trained in a non-AMSTI school. She was contacted by a member of the AMSTI team. In order to receive AMSTI training, the researcher had to guarantee that she would become a future trainer. With that position accepted, the researcher attended Summer Institute's two consecutive summers of 1 week of training in mathematics.

The researcher believes the AMSIT training was imperative to this study. The training enabled the researcher to understand what the AMSTI teachers were talking about in their interviews and discussions. It made the researcher more confident in her ability to interview the AMSTI teachers, and it provided some validity to her questions when she interviewed the non-AMSTI teachers.

Not only was the training helpful with this study, the researcher also uses several strategies she learned at the Institute. The most frequently used strategy is the "numbered

fingers” to teach struggling students with multiplication facts 6 through 10. She uses student journal writing and an AMSTI strategy for finding all the factors possible for a product. Also, she noted in the teacher’s mathematics textbook where AMSTI can be pulled into the curriculum she is presently using in the classroom.

The researcher believes AMSTI is a valuable program; however, she believes there are numerous changes that need to be made with the curriculum. A coordinated effort should be made to create (a) a complete curriculum textbook that meets the mandated requirements in the classroom; (b) locally, created pacing guides should match the pacing of the textbook; and (c) appropriately coordinated with the requirements of the course of study and the SAT 10 and ARMT assessments. The textbook should be structured to incorporate appropriate practice of the new skills being taught along with the repetition of basic skills. The pacing of the skills must be suitable in order to teach the skills that will be tested in early spring on the state mandated achievement tests. The activities must be valuable and must fit into a 50-minute class period. Additionally, some of the AMSTI activities should be formatted the same as the questions and problems found on the standardized achievement tests so the teacher does not have to take valuable class time to familiarize the students with the way the tests formats the questions and problems.

CHAPTER 4

ANALYSIS OF DATA

The purpose of this study was to determine if there was a difference in student achievement in mathematics between those students in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and those students in non-AMSTI classrooms in Grades 4 and 5. In addition, this study sought to determine the perceptions of teachers who had been trained in AMSTI strategies and use them in the mathematics classrooms as well as the perceptions of the teachers who had not been AMSTI trained. This chapter presents the analysis of the data that were collected from the study.

Research Question 1

The first research question asked: What are the differences between *Stanford Achievement Test (SAT 10)* mathematics scores of fourth- and fifth-grade students who have been instructed in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and students in non-AMSTI classrooms?

The *SAT 10* reports three separate mathematics scores: Total Mathematics, Mathematics Problem Solving, and Mathematics Procedures. For the purpose of this study, the total mathematics mean scaled scores were used in the analysis because they represented the combination of mathematics problem solving and mathematics procedures. According to Pearson Assessments, the distributor for the *SAT 10*, the scaled score is a conversion of a raw score. When comparing test results over time, scaled scores are valuable. The scaled score assists

changes to other score types, and it is appropriate for studying academic change in performance over a period of time (Pearson Assessment, 2010). The scaled scores were used for uniformity. They were used from the *SAT 10* because the *ARMT* uses them to present the scores of the students.

This first question sought to determine whether there was a statistically significant difference between the mean scaled score in mathematics on the *SAT 10* of the students instructed in AMSTI classrooms and students who were instructed in non-AMSTI classrooms. Two separate academic years were used in this study: 2008-2009 (2009 *SAT 10* scores) and 2009-2010 (2010 *SAT 10* scores).

Scores were analyzed using an independent samples *t* test. The mean scores and standard deviations for test scores for 2009 are presented in Table 4.

Table 4

Stanford Achievement Test Scores Tenth Edition in Mathematics: 2009

Schools	<i>n</i>	<i>M</i>	<i>SD</i>
AMSTI	4	650.75	6.292
Non-AMSTI	4	642.75	4.500

Table 4 shows the mean comparisons for the two groups' 2009 *SAT 10* scores in mathematics. The mean score of the AMSTI schools was 650.75 with the mean score for the non-AMSTI schools being 642.75. The data indicated there was no statistically significant difference in the mean score of the students in AMSTI schools and the mean score of the students in non-AMSTI schools, $t(6) = 2.068, p = .084$ with $\alpha = .05$. The average performance

score of the AMSTI schools ($M = 650.75$, $SD = 6.292$) was not significantly different from the average performance score of the non-AMSTI schools ($M = 642.75$, $SD = 4.500$).

Second, 2010 *SAT 10* scores for AMSTI and non-AMSTI students were analyzed using an independent samples *t* test. The mean scores and the standard deviations for 2010 *SAT 10* test scores are presented in Table 5.

Table 5

Stanford Achievement Test Scores Tenth Edition in Mathematics: 2010

Schools	<i>n</i>	<i>M</i>	<i>SD</i>
AMSTI	4	654.25	5.560
Non-AMSTI	4	640.25	14.221

Table 5 shows the mean comparison for the two groups' 2010 *SAT 10* scores. The mean score of the AMSTI schools was 654.25 with the mean score for the non-AMSTI schools being 640.25. The data indicated there was no statistically significant difference in the mean score of the students in AMSTI schools and the mean score of the students in the non-AMSTI schools, $t(6) = 1.834$, $p = .116$ with $\alpha = .05$. The average performance score of the AMSTI schools ($M = 654.25$, $SD = 5.560$) was not significantly different from the non-AMSTI schools ($M = 640.25$, $SD = 14.221$).

Research Question 2

The second research question asked, What are the differences between *Alabama Reading and Mathematics Test* (ARMT) mathematics scores of fourth- and fifth-grade students who have been instructed in AMSTI classrooms and students in non-AMSTI classrooms?

Two separate academic years were used in this study: 2008-2009 (2009 *ARMT* mathematics scores) and 2009-2010 (2010 *ARMT* mathematics scores). The *ARMT* mean scaled score is the measure of achievement presented on the *ARMT* report; therefore, it was used in the analysis. Using the aggregated data from the 2009 *ARMT* and 2010 *ARMT* reports, this question sought to determine whether there was a statistically significant difference between the mean scaled score in mathematics of the students instructed in AMSTI structured classrooms with students who were instructed in non-AMSTI classrooms.

First, using the 2009 *ARMT* report, scores were analyzed using an independent samples *t* test. The mean scores and standard deviations for the *ARMT* scores for 2009 are presented in Table 6.

Table 6

Alabama Reading and Math Test Scores in Mathematics: 2009

Schools	<i>n</i>	<i>M</i>	<i>SD</i>
AMSTI	4	651.425	3.783
Non-AMSTI	4	648.800	13.487

Table 6 shows the mean comparisons for the two groups' 2009 *ARMT* scores. The score of the AMSTI schools was 651.425 with the mean score for the non-AMSTI schools being 648.800. The data indicated there was no statistically significant difference in the mean score of the students in AMSTI schools and the mean score of the students in non-AMSTI schools, $t(6) = .375, p = .721$ with $\alpha = .05$. The average performance score of the AMSTI schools ($M = 651.425, SD = 3.783$) was not significantly different from the average performance score of the non-AMSTI schools ($M = 648.800, SD = 13.487$).

Second, 2010 *ARMT* scores for AMSTI and non-AMSTI students were analyzed using independent samples *t* test. The mean score and the standard deviation for 2010 *ARMT* test scores are presented in Table 7.

Table 7

Alabama Reading and Math Test Scores in Mathematics: 2010

Schools	<i>n</i>	<i>M</i>	<i>SD</i>
AMSTI	4	656.650	9.315
Non-AMSTI	4	649.175	19.560

Table 7 shows the mean comparison for the two groups' 2010 *ARMT* scores. The mean score of the AMSTI schools was 656.650 with the mean score for the non-AMSTI schools being 649.175. The data indicated there was no statistically significant difference in the mean score of the students in AMSTI schools and the mean score of the students in the non-AMSTI schools, $t(6) = .690, p = .516$ with $\alpha = .05$. The average performance score of the AMSTI schools ($M = 656.650, SD = 9.315$) was not significantly different from the average performance score of the non-AMSTI schools ($M = 649.175, SD = 19.560$).

Research Question 3

The third research question asked, What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have received AMSTI training?

To collect qualitative data, 11 individual interviews were recorded and transcribed for the AMSTI teachers. The researcher read and reread the interviews noting certain dominate categories from the data. After reading through the transcribed interviews, studying the

categories of the data, and becoming aware of the patterns, three themes arose: (a) impact on teachers, (b) impact on students, and (c) time for AMSTI.

Impact on Teachers

All AMSTI teachers had comments about how AMSTI had impacted their classrooms. Reading through the interview responses it was easy to determine that a mathematics teacher's day was influenced by more than the AMSTI curriculum. Unanimously, the teachers agreed that even though they were mostly pleased with their training, implementing AMSTI was challenging and that there were several obstacles that kept them struggling to teach the curriculum necessary to meet the mandated requirements. AMSTI's impact on the teachers included their training experiences, the teachers' difficulties in managing curriculum requirements and AMSTI, the additional amount of material needed to implement AMSTI mathematics, and the influence AMSTI had on their instruction.

Most AMSTI teachers found the training to be informative and beneficial. One teacher said, "The training helped me tremendously. There was so much involved to teaching AMSTI strategies and activities." Another teacher commented, "The training I received was top-notch. I had great AMSTI instructors that helped me think about teaching math differently."

One teacher said, "I think it [AMSTI] is a terrific program, but it certainly takes more than 1 year to feel comfortable teaching it. There is a lot to take in." Another teacher agreed. She said, "I really enjoyed my training experiences. I thought it was great. It was a little overwhelming. Showing me how to help the different types of learners, put teaching in a different light for me."

Other teachers commented about their training experiences. One teacher said,

My training was really good. The training is as good as the person who is presenting. I was fortunate to have good instructors for both Year I and Year II. The training was somewhat overwhelming because there was so much information presented so quickly, but it helped me be more confident in my work with the students.

One teacher said, “The trainers I had were very qualified, motivating, and effective. They both had very good arguments for the implementation of AMSTI in the classroom. The trainers changed what I had been thinking about AMSTI.” Another teacher commented, “Summer AMSTI training showed me how to teach math by making me the student. This new role taught me ways of looking at problems differently.”

Along with the teachers’ training experiences and its impact on them, the teachers discussed the challenges of balancing AMSTI and the mandated curriculum. All 11 teachers had comments about the difficulties of meeting the requirements of the pacing guide, benchmark tests, and standardized tests. One teacher commented,

The skills on our pacing guide and the benchmark tests we were required to give didn’t align with the AMSTI curriculum [Benchmark tests are periodic tests based on the scheduled coverage of skills in the textbook]. When I worked with the AMSTI curriculum, I was not following the pacing guide. If I don’t follow the pacing guide, my students do poorly on the benchmark tests. Then, there is the *SAT 10* and the *ARMT* tests that I don’t feel like I properly prepared the students for.

One teacher said, “I still can’t figure out how to do the course of study, the pacing guide, do well on the benchmark tests, and teach everything in the AMSTI books.” Another teacher said, “It was really overwhelming to try to fit everything into a class period.”

Another teacher commented,

Upper [elementary] grades face the challenges of standardized testing which drives so much of what we do. Many components of AMSTI seemed wonderful, but they were not all driven by what it took for students to perform well on the standardized tests they were given. Regardless of what I taught, standardized tests were still going to be given every year.

One teacher responded with, “We have a pacing guide, and it influenced what I taught in the classroom. Sometimes I felt limited to it.” She continued to say she did not hold the pacing guide as “God.” She said she took into consideration her students’ needs first. She said it was very difficult to meet all the curriculum requirements and teach AMSTI. Another teacher agreed with this difficulty and stated,

Our school system does have a pacing guide that we were required to follow. We were supposed to be following it at all times, which made implementing AMSTI very difficult. The order of concepts on the pacing guide did not align well with the suggested order of AMSTI. One of the biggest problems was that with the pacing guide came the benchmark tests. They were not aligned with AMSTI instruction. It was extremely difficult to follow two Masters--almost impossible.

Another teacher agreed by saying, “We either did well with the progression of AMSTI or did poorly on the benchmark tests, or vice versa. This was one major drawback to being an AMSTI school.” She continued by saying, “The pacing guide, the benchmark tests, and standardized tests influenced the AMSTI activities that I used or omitted.” Another comment was, “AMSTI didn’t align with what was on the pacing guide. We couldn’t fully implement it because, well, we had to get in what we could that was on the pacing guide first, then what was on AMSTI.”

One teacher commented further about the pacing guide. He said, “To follow the pacing guide, I jumped around in three large textbooks. I can’t imagine jumping around in the six unit books of AMSTI, too.” Another AMSTI teacher declared,

I couldn’t figure out how to do the course of study, the pacing guide, and teach everything in the AMSTI books. It was really overwhelming. I am self-contained. It was really hard to focus on every activity in AMSTI when I had other subjects to teach, and teaching AMSTI took a lot of preparation.

Another teacher added,

What I taught from AMSTI was influenced by the pacing guide. We followed the pacing guide closely because the unit tests and benchmark tests that we had to take followed it.

The pacing guide was one the central office came up with. It specified what came first and so forth. We all tried to work in AMSTI what we could, but we all followed the pacing guide very closely. This caused a lot of pressure on us.

In addition to curriculum concerns, teachers were concerned about additional materials that were needed such as multiple copies of activity pages from the AMSTI books. The teachers that said they used more AMSTI strategies and activities than others commented that they had to make too many copies from the six AMSTI unit books.

One concerned teacher said,

You have to run-off a lot of material if you go totally AMSTI. Our presenter said she ran-off a lot of copies. She didn't have a limit on the copies she made, but we do have a limit. We have to pay for copies over our limit.

Another teacher commented that she was in favor of a workbook instead of making copies of the activities for the students. She said, "AMSTI needed a workbook so the kids had something to go by other than copies I made." She explained that she had a limit on the number of copies she could make each year, and with a workbook, parents could easily see what their child was doing. One teacher stated,

I used the Student Activity sheets to have materials for problem-solving. I tried to learn enough about my students to pick the activities that would benefit them the most, so I didn't have to make copies of the activities that I felt were redundant or impractical for my students.

Two other teachers commented about making copies. One teacher said, "Sometimes I thought there were a lot of things to run-off where the students had to have a piece of paper in front of them." Another teacher added, "Running copies was difficult since our copies were limited, and we didn't receive a fee allocation to cover the extra expense."

Even though AMSTI created some challenges, it did appear to have influenced the teachers' instructional strategies. One teacher said,

My instructional strategies have shifted due to AMSTI. I now utilize a combination of the Harcourt math series and AMSTI strategies. I do a lot more grouping activities and partner work. Problem solving was a major focus in my classroom.

Another teacher said what she had learned through AMSTI was to teach different methods to solving problems. She said, “I show my students at least one way other than the traditional way to solve addition, subtraction, multiplication, and division problems.”

One teacher had a strong comment about AMSTI. She said, “I think it has made me a better teacher. I used more group work. I used more manipulatives individually and in groups. I was more flexible with my teaching.” Another teacher said, “AMSTI has made me look at some things differently. The students loved the manipulatives and the games we used in class. The manipulatives were very important when I introduced new skills.” Another teacher added that he made sure to do journaling regularly. He thought this gave the students another opportunity to think through the skills they were working on and an opportunity to explain things in their own words.

Impact on Students

The second theme that arose from the interviews was the impact AMSTI had on the students. Teachers were vocal about AMSTI’s impact. They made comments about students’ work with problem solving, students’ active engagement of “doing math,” students working collaboratively, and academic achievement.

Problem solving, which is a focal point of AMSTI, was a topic mentioned by all the teachers. Their comments reflected how their students had learned with the activities and strategies they were teaching through AMSTI. One teacher stated that they were learning to problem solve because, “Many of the activities were focused on helping students understand the

‘why’ behind math more than the ‘how’ with the belief it would help them perform better with the ‘how’ in the long run.”

One teacher commented that, “AMSTI offered a more in-depth understanding of mathematical concepts and ideas about how to solve problems.” She explained that the students used their manipulatives and strategies they were working with to discover different ways to solve problems. She believed they thought through their problems more thoroughly. AMSTI gave them the ability to look at different approaches to solving the problems. She said,

AMSTI was fairly effective at helping students think and communicate mathematically instead of just working problems in isolation. The strategies used gave students some options for attack when faced with difficult math problems. They were better thinking “outside the box” to see other ways of doing something.

One teacher supported the idea of different approaches when she said, “One of the neatest things about the program was that it allowed students to do the same problem in more than one way.” Another teacher said, “Students learned new ways to approach math problems.” Yet another teacher responded with, “Solving problems in more than one way is a life skill that was difficult for them [students] in all realms of society and not just in mathematics.”

One teacher commented, “Many students throughout the school year came to me with new ideas about how to solve math problems. It [AMSTI] made them think differently.” Another teacher said, “I thought it was always a good thing to find new ways to solve problems.”

Three different teachers made comments about how the students worked on problems longer. The three teachers said that the students spent more time on solving their problems. One teacher said, “The students got so involved [with their problems]. I ran behind [the schedule] because they didn’t want to stop and put things up.”

One teacher was specific about the strategies she liked to use with problem solving and data. She said she used the Daily Data, which helped the students with their mathematical

thinking and problem-solving abilities. With the Daily Data, the students used problem solving to manage and organize the data. The teacher said that she worked with the students to solve the problems and make real-life connections. They used their journals to explain the solutions to their problems.

Four of the 11 teachers commented that AMSTI enabled the students to problem solve and make connections with real-life situations. The teachers pointed out that an important factor of AMSTI was that students saw mathematics as a part of real life. One teacher said,

AMSTI problem solving enabled the students to make learning real for kids. I thought it made learning fun, but I thought it made mathematics real to them plus they incorporated what we learned into their lives. For example, when we started making multiples, twos--and you made a list of twos, then threes, and things that you saw in fours and twelve--you know a dozen of eggs are 12. They related what they saw in their lives--like a pair of shoes--into their world of mathematics.

Another teacher supported the idea of real-life connections and commented that students retained better when they applied what they were learning to their daily lives. One teacher said, "It [AMSTI] gave students more practical, real-world type problems to work with. I believed this improved their problem solving."

Another important aspect of AMSTI's impact on students was how they stayed actively engaged "doing math." Teachers stated that students worked longer doing math and discussed solutions with each other. Five of the teachers expressed their excitement about how students were engaged while they worked together and used different approaches and strategies in their problem solving. One of the teachers commented that anything hands on they loved it and worked at it longer. Another teacher commented that the students stayed on task. She said, "What had happened in math was that my children were more actively engaged. It [AMSTI] made learning fun. It helped them learn and move past the concrete, operational stage. I believed it made mathematics real to them."

Another teacher said AMSTI kept his students engaged through hands-on activities with manipulatives. He said, “The students stayed engaged and really liked the manipulatives. They worked at solving problems longer.” One teacher commented, “The students really enjoyed the games and activities. They worked longer on their problems, and they didn’t want to put them away at the end of class.” Another teacher said, “The kids love the manipulatives and games they used. They didn’t want to stop.” And, from another teacher, “The students stayed more engaged with learning as they worked with the manipulatives and each other.”

A third aspect of the impact on students was collaborative work. One teacher said, “The grouping with AMSTI provided students with many opportunities to work collaboratively.”

Another teacher responded,

When the students worked collaboratively, it allowed them to be in a more relaxed environment where it was okay to take risks and be wrong sometimes. It allowed them to work with someone a lot, which helped some students become better at math. Sometimes students learn from each other better than they learn from the teacher. I have seen some students who did not think they liked math at all decided they did like math after having been in the AMSTI classroom for awhile.

Another teacher explained how collaborative grouping impacted her teaching. She said she had more group work now than before AMSTI training. Before training, it was a more individual-learning approach in mathematics class. One teacher added,

When we first started working in groups, the students were really timid and wouldn’t discuss how to do the problems, but after they worked together and with their manipulatives, it was like a light turned on. ‘Oh, yes! We can do this.’ Then they were ready to help each other.

Another teacher responded by saying, “With AMSTI strategies, they [students] experimented for an answer. It was okay to be wrong, but they worked together to start over and get it right.” One teacher stated she really liked the collaborative work. She said, “They even were required to problem solve to find solutions for the group when someone was not working or

doing their part as they should.” The other teachers responded that they liked to have their students in groups working together. They said as they walked around the room they heard the students discuss how to solve the problems and how excited they got when the teacher agreed with their answers.

The teachers had constructive things to say about AMSTI; however, not all the comments were positive about student impact. One teacher commented:

One major problem I saw with AMSTI was a lack of repetition and practice of basic skills that is very important. There may only be three or four problems to focus on each day. I just feel students need time and practice on the skills being taught. Drill and practice is important in mathematics if students are going to remember how to work the problems in the future.

Another teacher said,

Overall, we work fewer math problems. Sometimes this can be good because we can focus a lot more, but sometimes this is not good because the students do not seem to get enough practice. AMSTI teachers just have to know to stop and add this practice when necessary.

Another teacher referred to the lack of drill and practice as being a weakness of AMSTI.

She commented,

For me, a major weakness of AMSTI was the lack of drill and practice. There was no repetition of basic skills. When you have taught math for many years, you know what the students need to practice over and over to be successful and be able to retain the basic skills that is necessary to build upon. Again, I think AMSTI mostly is about teaching the ‘why’ behind math more than the ‘how.’

Teachers shared their opinions about how their students worked on problem solving, about their “doing math” while working collaboratively, and how repetition of basic skills was minimized with AMSTI. They also had opinions about how AMSTI impacted their students’ academic achievement. Some comments were more positive than others. One teacher said:

I couldn’t really comment about *SAT* scores. I didn’t really have any concrete statistics. But in my teacher observations, after 35 years of teaching in education, I would have to

say they [students] were successful using those techniques more than the rote memorization of math and those type things.

Another teacher replied, “I do feel the students came to an understanding of the material quicker. But, I don’t have any proof of their achievement other than my observations.” Two other teachers commented that they really couldn’t say at this point of using AMSTI. They did not have anything to compare.

Another teacher commented, “I can see how my students communicate with each other, how they solve problems better, and with their general attitude about math that they have come a long way with their math achievement.” Two teachers believed that their test scores had come up a little bit. Two teachers expressed that they were not sure if their students’ achievements had improved. Other responses included the uncertainty of a rise in test scores; however, they responded that their students have become better problem solvers. One teacher said, “Well, if I had become more proficient with it [AMSTI], it would have really helped my kids. It depended on me, and I have to get more comfortable with it and learn more.”

Time for AMSTI

The third theme that became apparent from the interviews was the time factor. All the teachers commented during their interviews that they struggled to work AMSTI strategies and activities into their daily schedules. All the teachers talked about being pushed by the required curriculum and having to have found a way to squeeze in AMSTI strategies and curriculum.

One teacher reflected on the time constraints that she faced every day. She said that there was just not enough time to follow the mandated curriculum and implement AMSTI. She commented, “Time constraints and testing made trying to do both AMSTI and *Harcourt Math* overwhelming.”

Another teacher said:

I thought it [AMSTI] was a good program, but you needed to have time to really work with it [AMSTI]. We changed classes and by the time we got our kids to the restroom, the water fountain, and then settled down, I might have had 45 minutes to teach math. To have been really effective with it [AMSTI], you needed a good block of time.

One teacher said that if they could have just created more time during the school day he could have taught AMSTI to its fullest. He said, "I was not able to squeeze it [AMSTI] in as much as I should have. Time had not allowed me to do it all." Another teacher said,

I think some activities and lessons were really good, but there were some that I felt were a waste of time. I didn't have the time to do every little thing in the books. I had to make decisions on what was best for my students.

Another teacher had similar feelings. She commented that she tried her best to keep up with the curriculum she was required to teach. She said, "We all tried to work in what [AMSTI] we could, but with everything we were required to cover, it was really difficult. I didn't feel like I was very successful at it." Another teacher said time was an issue. She said:

I tried to pick the activities that would benefit my students the most. I did not utilize all the activities. Some of them took too much class time. Some of the activities were just not practical. They might have been wonderful and worked great, but there was just not enough time to do it all.

Another AMSTI teacher said, "I found it difficult sometimes to implement AMSTI in the classroom as opposed to traditional teaching, but I worked hard to find the time to use it more often." One teacher had this to say, "The main weakness of AMSTI in the classroom would be a time management issue--time to prepare for AMSTI--time to implement it."

Research Question 4

The fourth research question asked, What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have not received AMSTI training?

Along with interviewing the AMSTI teachers, non-AMSTI teachers were interviewed, also. To collect qualitative data, 10 individual interviews were recorded and transcribed for the non-AMSTI teachers. The researcher read and reread the interviews noting certain dominate categories from the data. After reading through the transcribed interviews, studying the categories of the data, and becoming aware of the patterns, two themes arose: (a) expectations of AMSTI, and (b) time constraints.

Expectations of AMSTI

Because the non-AMSTI teachers had not received AMSTI training, they were unsure about what to expect from the AMSTI program; however, most teachers' expectations were about the students working "hands on" in mathematics class. All 10 teachers discussed their expectations about AMSTI along with what they thought would be time issues in the classroom.

One teacher said she expected to see students working with manipulatives in mathematics class. She said, "I saw AMSTI as a way to teach students using a hands-on approach with manipulatives. Students are active participants in the learning process. Learning opportunities are more meaningful and the students' likelihood of retention of the content is increased." Another teacher said, "My understanding is that AMSTI is quite a bit of hands-on work; all materials and manipulatives are supplied; and lesson plans and books are provided for the teacher to use with the students."

Another teacher said, "I thought it [AMSTI] would be good because it is hands on. I like it because of the hands-on opportunities, and they bring materials to you to use with the students." She continued to say that she believed that children who worked with the manipulatives would be more involved. She expected the students to be more focused and learn

more. She also thought that AMSTI had small grouping incorporated with the class work.

Another teacher expected AMSTI to be a good program. She said she believed that AMSTI Lead Teachers would come to observe her and this would make her more accountable. She expected this to be a good thing.

Other teachers agreed with her. One teacher said, “Hands on is always good.” “Finding out new ways to do things to help children learn is good,” commented another teacher. And, one teacher said,

I believed AMSTI would include teachers and students working with manipulatives to problem solve, and the students would be engaged in the learning of math. I thought the problems the students would be working on would be real-life situations the students encountered outside of math class. I thought that anything we would need would be furnished for our students to use.

Another teacher felt strongly about her perceptions. She said,

I thought it [AMSTI] would be good because it would be hands on. If children were working hands on, they were involved. They focused better. It [the skill] just came to them a lot better. I liked it because of the hands-on opportunities. With them bringing supplies to you, it would be great.

Two teachers had similar comments. All they had heard about AMSTI was that it was more problem-solving based and the students worked more with manipulatives. Both commented that they believed this would help their students in mathematics. Another teacher said, “I believe AMSTI would provide us with materials and help us plan. It could give us fresh new ideas proven to work.” Another teacher had more to say about her expectations of AMSTI:

I thought AMSTI would be a good program because it was hands on. I taught in the lower grades, and I taught by modeling and had the children use their manipulatives. I have always taught this way. Then when I moved up to fourth grade that is how I started out. I began with manipulatives, then pictorial, then moved to abstract. Children with special needs or children who have a harder time understanding mathematical concepts excel when you use manipulatives. I used graphic organizers, also. I used anything to help them know what math was. I know AMSTI brings in both of these plus it brings in technology.

One teacher added,

From my discussion with other teachers and what I have heard, AMSTI was not so much text book driven. It presents things differently through games and problem-solving activities. Many teachers had reservations about AMSTI because there wasn't a text book for the students, only unit books for the teacher.

Another teacher had a different idea about AMSTI. She said, "I thought AMSTI would provide a type of inquiry learning where a lesson started out with a question and the students worked together to find the answer."

Along with the teachers' perceptions of AMSTI curriculum and activities, the teachers voiced their concerns about another important issue--time. Although the teachers had never experienced AMSTI in the classroom, most teachers had some ideas about how teaching AMSTI strategies and activities could modify their instruction of mathematics.

Time Constraints

One teacher was very frank about AMSTI. She said, "My concern was about time. We don't have enough time now, and we are not doing AMSTI." Another teacher said that time was a big factor. She explained that teachers were already required to teach certain mandated skills in a particular order. She questioned whether AMSTI would fit or replace what she was doing now.

Another teacher said she had heard from some local teachers that some of the AMSTI activities took too much class time. She said, "We had limited time in math class. We changed classes and no matter how hard I tried, I never had enough time. I wondered what we would do with AMSTI activities and how we would make everything fit."

A teacher said, "Time had always been an issue, especially in math class. I questioned how I would manage all the skills necessary to meet our curriculum requirements and implement AMSTI." Another teacher said, "I worried about having enough time. I thought maybe AMSTI

had a different approach to implementing the curriculum. I wasn't really sure what to expect. I just know time is a problem now."

Another non-AMSTI teacher said, "Our schedule was so tight, I was not sure what AMSTI would do to the curriculum requirements we already had in place." She said that she could not teach any more math concepts into the time she had now.

Time continued to be an issue with the teachers. One teacher commented,

One concern that I had when I went to the informational workshop was 'Can I do this and keep up with what I have to teach already?' Sometimes during the year you are struggling to stay up with your curriculum guide. I really didn't know how this was going to work.

Another teacher said, "Honestly, I don't know very much about AMSTI, just some things that I had heard. I had heard AMSTI's order of concepts didn't follow our curriculum schedule." He continued to say that they were under a great deal of pressure to teach the mathematics concepts in order and if that order changed along with what was to be taught, would there be time to teach everything that was required of them. He said, "Time is such an important issue daily. I am not sure what we will do to make AMSTI work in our situation."

CHAPTER 5

FINDINGS AND CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this study was to determine if there was a difference in student achievement in mathematics between those students in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and those students in non-AMSTI classrooms in Grades 4 and 5. In addition, this study sought to determine the perceptions of teachers who had been trained in AMSTI strategies and use them in the mathematics classrooms along with the perceptions of the teachers who had not been AMSTI trained. The research questions were as follows:

1. What are the differences between *Stanford Achievement Test* (SAT 10) mathematics scores of fourth- and fifth-grade students who have been instructed in Alabama Math, Science, and Technology Initiative (AMSTI) classrooms and students in non-AMSTI classrooms?
2. What are the differences between *Alabama Reading and Mathematics Test* (ARMT) mathematics scores of fourth- and fifth-grade students who have been instructed in AMSTI classrooms and students in non-AMSTI classrooms?
3. What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have received AMSTI training?
4. What are the perceptions concerning AMSTI of the fourth- and fifth-grade teachers who have not received AMSTI training?

Findings and Conclusions

Student Achievement

The analysis of the data showed that for both academic years of 2008-2009 and 2009-2010, the AMSTI schools showed no significantly higher scores in mathematics in Grades 4 and 5 than the non-AMSTI schools, when measured by the *Stanford Achievement Test Tenth Edition (SAT 10)*. The analysis of the data also showed that for both academic years 2008-2009 and 2009-2010, the AMSTI schools showed no significantly higher scores in mathematics in Grades 4 and 5 than the non-AMSTI schools, when measured by the *Alabama Reading and Mathematics Test (ARMT)*.

The findings in this study concerning no significant difference in mathematics achievement between students in comparable AMSTI and non-AMSTI schools are supported by Stewart (2008) who found that there was no statistically significant difference in the achievement scores between AMSTI and non-AMSTI schools. According to Stewart, when student achievement data in the 16 original AMSTI elementary and middle schools were compared with 16 demographically similar non-AMSTI schools, the analysis showed that AMSTI was not making a significant difference in student achievement in the AMSTI schools as compared to the demographically similar non-AMSTI schools. However, all available promotional and assessment information distributed by AMSTI (Alabama State Department, 2009) indicated that significant differences do exist. Perhaps the research done by AMSTI needs to be scrutinized more carefully for statistical parameters and accuracy since none of that particular information is available on the website, which is the only source of information for the public.

Because this study was conducted only in Grades 4 and 5, it is possible that there are not significant differences between AMSTI and non-AMSTI schools at these grade levels but that

when total schools K-5 are taken into account, differences may occur. Teachers of Grades 4 and 5 are much more concerned with the standardized test results than are lower grade teachers, many of whom do not have to give these tests. Teachers in Grades 4 and 5 may be more concerned with teaching to the objectives on these tests and less concerned with teaching AMSTI. Also, the philosophy of AMSTI, along with the materials, aligns better in the lower grades because most of those teachers already use many of the fundamentals of AMSTI such as manipulatives, math centers, and group work. Grades 4 and 5 teachers may not believe they have enough time to do this additional work.

All of the teachers commented that time was an issue in implementing AMSTI. Often comments were made about having to squeeze in AMSTI strategies and curriculum in between meeting mandated curriculum requirements and the pacing guide. One teacher commented, "I am not able to squeeze it [AMSTI] in as much as I should have. Time had not allowed me to do it all." Other comments included time constraints and testing made trying to do the mandated curriculum and AMSTI overwhelming; couldn't really implement as much as I liked; picking out AMSTI activities; tried to work in AMSTI what we could. Also, another factor could be the length of time the teachers had been involved with AMSTI. One school became an AMSTI school in 2006 and the other school in 2008. Loucks-Horsley et al. (1998) stated that most research takes 3 to 5 years for teachers to develop a routine of using a new program. All of these comments could support why this study found there was no significant differences in the AMSTI students' scores and the non-AMSTI students.

Loucks-Horsley et al. (1998) acknowledged that there are benefits to using curriculum implementation as a "vehicle" for professional development, but there are "pitfalls," also.

Tension occurs when the mandates to implement new curriculum with fidelity conflicts with the curriculum requirements and teacher creativity already in place. Teachers must know specifically how much adaptation they can do and still be viewed as implementing the curriculum effectively.

Even though there were no significant differences between the two groups of students on the *SAT 10* and *ARMT* mathematics scores, the AMSTI teachers had a lot of uncertainty about the influence of AMSTI on student achievement. Some teachers were confident that AMSTI had improved students' academic achievements, while other teachers were uncertain about AMSTI's influence. Teachers said that since they did not have *SAT 10* or *ARMT* scores supporting student achievement, they had no concrete statistics backing up any improvements in student achievement in mathematics. Most teachers commented that they were not sure if their students' academic achievement had improved, while the teachers who acknowledged improvements based their perceptions on observations only, not on actual data.

Largely because of the *No Child Left Behind Act* of 2001, student achievement and teacher evaluations are intertwined. Teachers know that success on their evaluations is tied closely to student achievement. Most teachers perceive themselves to be good teachers no matter what curriculum changes happen to be mandated. Because of this it is possible that the teachers do not believe that AMSTI accounts for their students' achievement in mathematics. They may believe that they, themselves, are the instruments of student academic success. In fact, research conducted by Ashton and Webb (1986) supported this idea. They found that teachers who perceived themselves as having a high sense of efficacy are confident that they are able to influence students' academic learning and success.

AMSTI Teachers' Perceptions of the Program

For the most part, AMSTI teachers reported their training to be informative and beneficial. However, the teachers commented about how overwhelming the training was and that an important part of that training was the quality of the trainer. They reflected on the importance of the trainer being qualified, motivating, and effective and how the trainer had changed their perceptions of AMSTI mathematics. Research by Crandall (1983) identified the trainer as one of the most important elements of professional development. The trainer must be viewed as dependable and possessing the ability to demonstrate how the new practices can be effectively and efficiently used in the classroom.

The teachers also mentioned the challenges of including AMSTI into the daily mandated curriculum requirements. They commented that the limited time and the curriculum requirements that were already in place before the implementation of AMSTI severely limited or impeded their ability to use and teach AMSTI strategies and activities. Also, the teachers felt the structure of the AMSTI curriculum was difficult to manage due to the six curriculum books they had to use and the multiple copies of activity pages they had to reproduce.

Teachers specifically noted the fact that the pacing guide, the benchmark tests, and the preparation for the standardized tests influenced the AMSTI curriculum that were used or omitted in their classrooms. When the AMSTI curriculum did not align with the pacing guide that was created to keep the teachers on schedule for completion of the skills that would be on the standardized test in early spring, the teachers responded that because of the time issue they had to teach what was on the pacing guide first and then what they could teach of AMSTI. Research by Battista (1999) showed that teachers make instructional decisions, guided by outside pressures to guarantee that students are successful on high-stakes tests (Manouchehri &

Goodman, 1999). In addition, the teachers asserted that AMSTI had influenced their instructional strategies. They indicated that they used more collaborative work, utilized manipulatives more, and focused on different approaches to problem solving. Teachers also had positive perceptions about how AMSTI impacted their students.

The teachers were very vocal about AMSTI's impact specifically noting the students' work with problem solving, students' active engagement of "doing math," and students working in collaborative settings. Darling-Hammond and McLaughlin (1995) supported the idea that teachers need to understand subject matter deeply and flexibly and make connections to everyday life through problem solving and teach these connections to their students.

The teachers perceived that their students were more interested in mathematics and more motivated to learn. Bay et al. (1999) indicated the attitudes of the students are important to the learning process. Students who are actively engaged in their learning have an increased opportunity to master mathematical concepts and problem solving abilities that are promoted by the PSSM (Fuson et al., 2000; Riordan & Noyce, 2001).

It seems that AMSTI training had some effect on instructional practices of the teachers. The teachers had changed their ways of teaching and learning mathematics in the classroom. Perhaps the reason for this was due to the obligation the teachers felt because they had been trained and were expected to use the AMSTI strategies. In addition, they knew they would be receiving follow-up visits by AMSTI personnel and would probably want to make a good impression during those visits by showing how the AMSTI principles were being carried out in their classrooms. Also, since the training was so intensive and so recent, the teachers may have been excited to try the new methods in their classrooms even though they found it challenging.

Non-AMSTI Teachers' Perceptions of the Program

The non-AMSTI teachers' perceptions were concerned with the expectations of AMSTI, how much time it would take to do the AMSTI training and implementation, along with their perceptions as to why they are not an AMSTI school. Most teachers expected AMSTI to be based on working with manipulatives. Their comments focused on how AMSTI would incorporate hands-on activities with manipulatives to help the students stay more focused on their learning. They also had comments about students working collaboratively with problem solving. Some teachers thought there would be more group work where students work as a team to solve problems and find solutions to inquiry type questions.

Another perception the teachers discussed was the issue of time. They were concerned that time would be an important factor to consider before implementing AMSTI. Most teachers said that there is not enough time now to teach the required curriculum and stay on schedule in the timeframe they are given. Teachers' perceptions were primarily formed based on what they had heard and interpreted from conversations with other teachers. They were unsure about many things about AMSTI; however, they were sure they would be challenged to incorporate the required curriculum along with the AMSTI strategies.

The non-AMSTI teachers were operating under information gathered from other teachers who mostly had participated in the AMSTI training. However, some of their information was just hearsay. They knew that AMSTI involved the use of manipulatives, which most of them had probably seen in their undergraduate work. Upper-grade teachers rarely use manipulatives in their teaching of mathematics so these teachers may have thought that the use of manipulatives would be time consuming, although they did appear to see the value of using them. Research has promoted the use manipulatives as a way to help students form internal representations of the

skill being studied; however, in a study conducted by Sherman and Richardson (1995), teachers chose not to use them. They cited the reasons as being too time consuming while receiving poor results from the students.

When questioned why their schools were not AMSTI schools, the teachers were unsure because they had not been given the opportunity to vote on becoming AMSTI trained. However, since the teachers and administrators in those schools had already participated in one time-consuming state initiative (the Alabama Reading Initiative [ARI]), it may have been that those in charge of putting AMSTI to a vote in those schools decided against it due to the amount of time it would take.

Implications

1. Any new program or curriculum that is being introduced or mandated should align with the requirements of the school district. Otherwise, an additional layer is added for the teachers to sort through to insure they are meeting the requirements of the school district (as well as state requirements) and meeting the intent of the new program or curriculum.

2. Trainers must be carefully selected for professional development due to the impact they have on teachers' attitudes and the implementation of the new curriculum.

3. During professional development teachers must be prepared for the additional work load that will be expected of them during the first couple of years of implementation of a new program.

4. Instructional strategies and teachers' attitudes can change dramatically as a result of professional development that is appropriately implemented with a focus on effective classroom learning and teaching with student achievement in mind.

5. Any newly implemented curriculum should align with the locally created pacing guides. Also, the scope and sequence of the new curriculum should be structured to fit the timeframe and format of the state's yearly, mandated, standardized assessments.

Recommendations for Future Studies

This study investigated the differences in *SAT 10* and *ARMT* mathematics scores of fourth- and fifth-grade students who have been instructed in AMSTI classrooms and those in non-AMSTI classrooms. Perceptions of teachers trained in AMSTI, and teachers who had not been trained in AMSTI were examined. As a result of this study, the following recommendations are offered for future research:

1. To validate this study's results, the study should be completed with a larger sample size.

2. Qualitative studies should be carried out with the AMSTI trained teachers. These studies, which should include classroom visits, could provide more information about their instructional practices in mathematics than just the self-reporting from this study.

3. A future study should compare pre- and post-achievement scores of AMSTI and non-AMSTI students.

4. A similar study could be replicated in science.

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APPENDIX A

ALABAMA STANDARDS FOR PROFESSIONAL DEVELOPMENT

Alabama Standards for Professional Development
Alabama Department of Education*
Twelve (12) Standards for Effective Professional Development in Alabama

- Standard 1: Effective professional development organizes adults into learning communities whose goals are aligned with those of the school, the system, and the state.
- Standard 2: Effective professional development requires knowledgeable and skillful school and system leaders who actively participate in and guide continuous instructional improvement.
- Standard 3: Effective professional development requires resources to support adult learning and collaboration.
- Standard 4: Effective professional development uses disaggregated student data to determine adult learning priorities, monitor progress, and help sustain continuous improvement.
- Standard 5: Effective professional development uses multiple sources of information to guide improvement and demonstrate its impact.
- Standard 6: Effective professional development prepares educators to apply research to decision making.
- Standard 7: Effective professional development uses learning strategies appropriate to the intended goal.
- Standard 8: Effective professional development applies knowledge about human learning and change.
- Standard 9: Effective professional development provides educators with the knowledge and skills to collaborate.
- Standard 10: Effective professional development prepares educators to understand and appreciate all students; creates safe, orderly, and supportive learning environment; and holds high expectations for their academic achievement.
- Standard 11: Effective professional development deepens educators' content knowledge, provides them with research-based instructional strategies to assist students in meeting rigorous academic standards, and prepares them to use various types of classroom assessments appropriately.
- Standard 12: Effective professional development provides educators with knowledge and skills to involve families and other stakeholders appropriately.

*Alabama Administrative Code 290-4-3-.01: Resolution adopted: June 13, 2002
Classroom Improvement Leadership Development

APPENDIX B
INSTITUTIONAL REVIEW BOARD REQUEST

IRB Project #: 10-02-168

UNIVERSITY OF ALABAMA
INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS
REQUEST FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS

I. Identifying information

	Principal Investigator	Second Investigator	Third Investigator
Names:	Judy Bright		
	Faculty Adviser:		
	Dr. Julie Herron		
Department:	Curriculum and Instruction		
College:	Education		
University:	University of Alabama		
Address:			
Telephone:			
FAX:			
E-mail:	jherron1@hamed.ua.edu		

Title of Research Project: State-Wide Mathematics Initiative: Student Achievement and Teacher Perceptions in Grades 4 - 5

Date Submitted: March 14, 2010
Funding Source: Personal resources

Type of Proposal: New Revision Renewal Completed Exempt

	Please attach a renewal application		
Please attach a continuing review of studies form			
Please enter the original IRB # at the top of the page			

UA faculty or staff member signature: J. Herron

II. NOTIFICATION OF IRB ACTION (to be completed by IRB):
Type of Review: Full board Expedited

IRB Action:

Rejected Date: _____

Tabled Pending Revisions Date: _____

Approved Pending Revisions Date: _____

Approved-this proposal complies with University and federal regulations for the protection of human subjects.

Approval is effective until the following date: 5-24-10.5

Items approved:

Research protocol (dated _____)

Informed consent (dated _____)

Recruitment materials (dated _____)

Other (dated _____)

Approval signature: [Signature] Date: 5/25/2010

APPENDIX C

INTERVIEW PROTOCOL: AMSTI TEACHERS

Interview Protocol

AMSTI Teachers

1. Why did you become AMSTI trained?
2. What were your perceptions of the AMSTI program prior to your involvement in the AMSTI training?
3. What is your perception of the training you received in AMSTI mathematics?
4. Has AMSTI impacted your teaching of mathematics? How?
5. What are the benefits of AMSTI mathematics?
6. Has AMSTI impacted student achievement in mathematics? How?
7. Does your school have a pacing guide for mathematics? If yes, how closely do you follow the guide, and does the pacing guide have any influence on the AMSTI activities you teach in your classroom?
8. Why would you encourage (or not) other teachers in non-AMSTI schools to participate in the AMSTI program?
9. How well are you able to implement AMSTI mathematics into your classroom?
10. Have any changes occurred in your instructional strategies in mathematics as a result of AMSTI? Please explain.
11. Describe the strengths and weaknesses of AMSTI mathematics (both training and implementation).

APPENDIX D

INTERVIEW PROTOCOL: NON-AMSTI TEACHERS

Interview Protocol

Non-AMSTI Teachers

1. Why have you not become AMSTI trained?
2. What are your perceptions of the AMSTI program?
3. What are your perceptions of the AMSTI summer training?
4. How might AMSTI impact your teaching of mathematics?
5. What do you think are the benefits of AMSTI mathematics?
6. Do you think AMSTI impacts student achievement in mathematics?
7. Does your school have a pacing guide for mathematics? If yes, how closely do you follow the guide, and would the pacing guide be problematic if you were to be involved in the AMSTI program?
8. Would you encourage teachers in your school to participate in the AMSTI program? Why or why not?
9. What are your perceptions of how AMSTI is implemented in the mathematics classroom?
10. What plans does your school have for teachers to become AMSTI trained?