A STUDY OF ELEMENTARY TEACHERS’ PERCEPTIONS OF MATHEMATICS AND
SCIENCE TRAINING AND IMPLEMENTATION ON A
STATE MANDATED INITIATIVE

by

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ABSTRACT

This study investigated 89 K-5 elementary teachers’ perceptions of mathematics and science training, implementation, and practices in a state-mandated professional development initiative for classroom teachers, the Alabama Mathematics, Science, and Technology Initiative (AMSTI), and its impact in their classrooms as a result of participating in the Year 2 AMSTI Summer Institute. The AMSTI program was developed by the Alabama State Department of Education to engage teachers in reform in mathematics and science education. Reform occurs through professional development, providing the required materials, and on-site support for participants. Data sources included the AMSTI Mathematics Questionnaire, AMSTI Science Questionnaire, open-ended questions administered to 89 participants, and 6 focus group interviews. Mixed Factorial ANOVA tests were used to determine the effect of grade level and the subject (mathematics and science). Results indicated significant effects for science training in Grades 2, 3, and 5 and significant effects for science implementation in Grades 3 and 5. Overall, the teachers in this study had more favorable perceptions of the science training than the mathematics training. The science training and materials provided made it easier to implement the AMSTI training. Time was a determining factor for implementation and teachers were unable to implement as much of their training as was expected of them. Teachers in Grades 4-5 reported testing acted as barrier to teaching science when it was close to testing time. At all grade levels, teachers reported being exposed to more ways of teaching in mathematics and science. They noted the convenience of having all of the materials. They included more hands-on learning and more communication during mathematics and science classes. As a result of AMSTI training,
teachers appeared to exhibit the instructional practices recommended by national professional organizations and standards.
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Lore worth learning, learn flawlessly
Live by that learning thoroughly - Thiruvalluvar

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CHAPTER I

INTRODUCTION

The performance of U.S. students in mathematics and science compared at the national and international levels has indicated a need for reform in mathematics and science education in this country. In 1983, a report from the federal government’s National Commission on Excellence in Education, *A Nation at Risk*, raised concerns with its statement that low student achievement was a threat to America’s national prosperity and civic well being (National Commission on Excellence in Education, 1983). Since then, similar concerns have been expressed by education policymakers, business organizations, and national leaders.

As indicated by the National Commission on Mathematics and Science Teaching for the 21st century (NCMST), U.S. students will require proficiency in mathematics and science to live their lives and work at their jobs productively (NCMST, 2000). Moreover, the Business Roundtable (2005) expressed concerns with their prediction of jobs in the future. According to their prediction, in the U.S. jobs that require mathematics and science will double by 2015. They also added that along with higher mathematical and science knowledge, future employees are expected to have reasoning power and innovation skills.

Furthermore, the U.S. Department of Labor has projected in the decade ending in 2014 there will be 2 million job openings in the field of mathematics, computer science, engineering, and physical sciences. Echoing this, economic studies predict 8 out of 10 jobs in the future will be related to mathematics and science. There will be robust growth over the next 5 to 10 years in industries such as health care, education, transportation, and construction (Bureau of Labor
Statistics, 2009). The reports and predictions make proficiency in mathematics and science for the students in the U.S. a necessity, if they are to be prepared to meet the demands of the work force of 21st century.

According to a report by the National Science Board (2006), America’s pressing challenge is as follows:

If the U.S is to maintain its economic leadership and compete in the new global economy, the nation must prepare today’s K-12 students better to tomorrow’s productive workers and citizens. Changing the workforce requirements mean those new workers will need more sophisticated skills in science, mathematics, engineering and technology. . . . In addition, rapid advances in technology in all fields mean that even those students who do not pursue professional occupations in technological fields will also require solid foundations in mathematics and science in order to be productive and capable members of our nation. (p. 2)

Therefore, the U.S. has a need to generate a mathematically, scientifically, and technologically literate workforce in order to function and maintain its economic leadership and thus be able to compete globally. Current employers are interested in the employees’ abilities to identify, reason through, and apply content as well as skills to solve problems in the job, according to the National Council of Teachers of Mathematics (NCTM, 2000).

The necessity and applicability of mathematics and science indicates these are basic skills required for functioning in society. Ross (1998) stated one of the most important goals of mathematics and science is to teach the reasoning skills required in all facets of life. Students must have conceptual knowledge in mathematics and science. Furthermore, they also must know how to apply them to reasoning and problem solving (Cass, Cates, Smith, & Jackson, 2003). However, statistical evidence from international, national, and state reports indicates U.S students lack performance and proficiency in mathematics and science.

The need for improving mathematics and science performance and proficiency is seen in international reports such as the Third International Math and Science Study (TIMSS, 1995),
Program for International Assessment (PISA, 2000, 2003, & 2006), and Trends in International Math and Science Study (1999, 2003, & 2007). Similar needs have been echoed in national reports such as the National Assessment of Education Progress (NAEP). The TIMSS reports indicate an improvement in mathematics scores in 2003 and 2007 for fourth-grade and eighth-grade students. However, in 2007, the TIMSS reported that neither fourth nor eighth graders showed any detectable change in science achievement (National Center for Education Statistics [NCES], 2007a). Following the 1995 TIMSS, the Program for International Student Achievement (PISA) results were published (NCES, 2001). These reports also are used to determine students’ achievement in reading, mathematics, and science literacy (Lemke et al., 2001). Results from 2006 PISA show that U.S students performed low in math and science (NCES, 2006a).

Since 1990, the national performance in mathematics and science also has been measured by the National Achievement of Education Progress (NAEP). The NAEP reports indicate low achievement in mathematics and science in the country. In the reports published by NAEP in 2005, U.S. students in Grades 4 and 8 posted higher mathematics scores than students in the same grades in 1990. In science, however, the average scores increased for 4th grade students, held steady for 8th grade students, and declined for 12th grade students between 1996 and 2005 (NCES, 2006a; Neidorf, Binkley, Gattis, & Nohara, 2004). Reports indicate the 2007 and 2009 scores in mathematics and science show no significant change (NCES, 2009).

Despite the slight gains made in mathematics and science from 1990 to 2009, most 4th, 8th, and 12th graders do not perform at levels considered proficient for their grade level. The Nations Report Card 2000, issued by NAEP, indicated Alabama’s 4th grade and 8th grade students ranked lower than the national average in mathematics and science. The NAEP 1996
mathematics indicated at the fourth-grade level, 40% were below basic level, 48% were at or above basic level, 11% were at proficient level, and 1% was at advanced level. Also the NAEP 2000 mathematics indicated at fourth-grade level, 18% were below basic level, 57% were at or above basic level, 14% were at proficient level, and 1% was at advanced level. Similar results were also indicated for the eighth-grade NAEP mathematics. The NAEP 1996 mathematics indicated at eighth-grade level, 42% were at or below basic level, 45% were at or above basic level, 12% were at or above proficient level, and 1% was at or above advanced level. Compared with the nation, at the eighth-grade level, only 22% of Alabamians scored at or above proficient level, while the national average was 30% (NCES, 2006a). Looking at the statewide performance, the 4th and 8th grade students in the state of Alabama ranked 49 out of 50, placing in the fourth quartile in mathematics and science (NCES, 2009).

NAEP reports similar findings in science for the state of Alabama. In 1996, NAEP science was not administered to fourth-grade students. However, NAEP 2000 reports indicated at fourth-grade level, 17% were at or below basic level, 59% were at or above basic level, 22% were at proficient level, and 2% were at advanced level. The NAEP 1996 reports indicated at eighth-grade level, 35% were at below basic level, 47% were at or above basic level, 18% were at proficient level, and 1% was at advanced level. The NAEP 2000 reports indicated at eighth-grade level, 25% were at or below basic level, 51% were at basic level, 22% were at proficient level, and 2% were at advanced level. Therefore, reform measures had to be initiated to improve students’ performance in mathematics and science.

Due to these statistics, Alabama initiated the Alabama Math, Science, and Technology Initiative (AMSTI). The mission of AMSTI is to provide all students in Grades K-12 with the knowledge and skills needed for success in the workforce and/or postsecondary studies.
(Alabama State Department of Education, 2009). The AMSTI program was started by the Alabama Math, Science, and Technology committee (AMSTEC) formed in 1998 to investigate what had to be included to achieve successful teaching and learning mathematics and science in the state of Alabama. The purpose of this committee was to bring a systemic reform effort in mathematics and science education in Alabama. This committee was formed by a blue ribbon committee that was comprised of K-12 teachers, university faculty, policymakers, and business leaders who were collectively concerned about the lack of student achievement in Alabama (Alabama State Department of Education, 2009).

The committee reviewed the existing programs in Alabama and also in the nation, and compared national standards to Alabama state standards, and assessment data from the state of Alabama to the national norms. The result was an initiative that would be beneficial for teachers and students in improving mathematics and science education. Thus AMSTI was developed in 1999 to improve mathematics, science, and technology education in the state through professional development for teachers. The AMSTI program stated it is “research based and provides best practices through professional development for teaching mathematics and science” (Alabama State Department of Education, 2009, p. 2.).

The AMSTI provides three basic services: professional development, equipment and materials, and on-site support. Schools become AMSTI schools by sending their mathematics, science teachers, and administrators to the 2-week Summer Institute for two summers. At the Summer Institute, teachers receive grade and subject specific professional development that is highly applicable to their own classrooms. Instruction is delivered by “master” teachers who have been certified as AMSTI trainers (Alabama State Department of Education, 2009).
The AMSTI offers training focused on inquiry-based learning, hands-on instruction, improving problem-solving skills, reasoning, using real life experiences in teaching, effective questioning, using writing in mathematics and science, and using technology in teaching. Instruction utilizes research-based curricula, such as *Investigations* in mathematics and *Full Option Science System* in science, that were developed with support of the National Science Foundation (Alabama State Department of Education, 2009).

The purpose of AMSTI is to provide research-based and sustained professional development. As Johnson (2006) suggested, the purpose of professional development programs should be able to provide sustained training. Programs should focus on deepening of content knowledge for teachers (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Collective participation should be encouraged in addition to providing teachers with the resources they need to implement the program (Klingner, Ahwee, Piloneita, & Menendez, 2002).

The duration of professional development can be a determining factor in the teachers’ willingness to participate in the program. Many teachers need to learn new instructional methods, and workshops with fragmented topics may not serve that purpose (Johnson, 2006; Suppovitz & Turner, 2000). In addition, if information gained is contextual, such as addressing specific topics, when only a select few can benefit, teachers may not consider it as useful (National Research Council, 2000).

Furthermore, when teachers are the sole participants in professional development, they may not be willing to participate in the program (Desimone, Porter, Garet, Yoon, & Birman, 2002). If teachers do not have an opportunity to collaborate and discuss the new methods of teaching, their interest in participating in professional development programs may be reduced. The lack of support from administration and lack of resources may be other contributing reasons
for teachers’ unwillingness to embrace professional development programs. The success rate of a professional development program depends on how well it is accepted and implemented by teachers in their classrooms (Smith & Southerland, 2007).

Teachers are the key to successful reform and play a major role in improving student learning. Anderson (2002) suggested that much of the difficulty in enacting a reform is internal to the teacher, including the teachers’ perceptions in relation to students, teaching, and purpose of education. Because teachers play a major role in bringing reform to the classroom, their perceptions of the professional development program helps in understanding the benefits and limitations of the program.

However, the perceptions of teachers vary. Some teachers favor traditional methods of teaching that can serve as barrier to reforms, while other teachers have perceptions that closely align with the tenets of reforms and use inquiry-based instruction in their classroom (Southerland, Smith, Sowell, & Kittleson, 2007). Thus, there is a need to find out what teachers perceive about the professional development training they have received and how it translates to classroom instruction.

Statement of the Problem

Due to the academic demands in the areas of mathematics and science being placed on the rising work force in the United States, coupled with the poor performance of K-12 students in these disciplines, there is an urgent need to improve student achievement in these two disciplines. One of the ways to improve student achievement is through professional development for teachers. Due to the lack of effectiveness that could exist in professional
development programs, such as the duration, resources, and collaborative learning, teachers may not be willing or able to implement what they learned in professional development.

Teachers take the training from professional development to the classroom; therefore, they are instrumental in determining the success or failure of professional development programs. Hence, there is a need to find out what teachers perceive about the training they have received, and if what they learned is impacting their instructional strategies to align with the professional development they received.

The Alabama Mathematics, Science, and Technology Initiative (AMSTI) is a statewide professional development program offered to K-12 teachers in the state of Alabama. There is, however, lack of professional published research on AMSTI. The evidence of AMSTI’s effectiveness in respect to student achievement that does exist is presented on the AMSTI website with no way to determine how the statistics were cited. There is no professional research published or presented on the AMSTI regarding teachers’ perceptions of their training and implementation of AMSTI in their classrooms. In addition, no studies have been done on second-year AMSTI trained teachers and their perceptions in both mathematics and science.

**Purpose of the Study**

Even though many factors could affect student achievement in mathematics and science, the purpose of AMSTI is to increase student achievement. The initiative is trying to create a program that would impact mathematics and science teachers which would lead to improvement in student achievement. Thus, the purpose of this study was to investigate two-year AMSTI trained elementary teachers’ perceptions of AMSTI and its implementation in mathematics and
science. Furthermore, this study examined whether changes in instructional strategies occurred in mathematics and science as a result of the AMSTI training.

Significance of the Study

This study may be valuable to the State Department of Education as it tries to get funding from Alabama Legislature to offer AMSTI training for all schools in Alabama. This study may also be useful to colleges and universities when they revise teacher education programs as they prepare pre-service teachers to meet state standards targeted on improving student achievement. Moreover, the results of this study can help restructure professional development at the state level. AMSTI trainers may be able to get information for revising, including, or excluding activities in the training. In addition, this study may provide information for administrators while planning effective professional development. Finally, this study may add to the existing literature on studies conducted with professional development programs.

Research Questions

1. Is there a difference in second year K-5 teachers’ perceptions of AMSTI training, implementation, and practices in mathematics and science across grade levels?

2. What are the second-year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in mathematics?

3. What are second-year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in science?

4. What are second-year AMSTI trained K-5 teachers’ perceptions of AMSTI mathematics?
5. What are second-year AMSTI trained K-5 teachers’ perceptions of AMSTI science?

Definition of Terms


AMSTI Summer Institute. A 2-week professional development in which teachers are grade specifically trained on how to use manipulatives in kits provided and how to use inquiry-based learning in their classrooms. (Alabama State Department of Education, 2009).

Professional development. A comprehensive, sustained, and intensive approach to improving teachers’ and principals’ effectiveness in raising student achievement (National Staff Development Council, 2007).

Inquiry-based learning. A classroom learning atmosphere in which students ask questions, plan investigations, collect, organize, and analyze data (National Research Council, 1996).

Hands-on learning. A classroom-learning atmosphere in which students use manipulatives to learn specific objectives (National Research Council, 1996).

Limitations of the Study

1. This study was limited to 89 participants who had completed their 2 years of summer training.
2. All participants were from six schools in Alabama, so the results are not generalizable to other teachers in Alabama.

3. Because participation in the interviews was voluntary, the responses may not reflect the views of all the participants.

4. Purposeful sampling was used for selecting interviewees; therefore, results cannot be generalized.

Assumptions of the Study

1. The participants understood all the items in the survey.

2. The participants’ responses to the survey were honest.

3. The information provided by the Alabama State Department of Education was complete and accurate.

4. The participants had the same opportunities to participate in AMSTI.

Organization of the Study

This study has been organized into five chapters. In the first chapter an introduction and information related to the need for this study are provided. The second chapter is the review of literature. This is comprised of elementary mathematics education, elementary science education, professional development, and state initiatives in mathematics and science. The third chapter is the methodology. This chapter explains the procedures used to gather data. The fourth chapter comprises the quantitative and qualitative analysis of this study. The last chapter consists of findings and conclusions, implications, and recommendations for further study.
CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to investigate elementary teachers’ perceptions of the Alabama Mathematics, Science, and Technology Initiative in mathematics and science to investigate the impact of training on classroom instructional practices in mathematics and science. The literature pertinent to this study is presented in the following sections: (a) elementary mathematics education, (b) elementary science education, (c) professional development, and (d) state initiatives in mathematics and science.

Elementary Mathematics Education

History of Mathematics Education

The Russians’ successful launch of Sputnik in 1957 caused concerns for both mathematics and science education in the United States. The American press treated Sputnik as a major humiliation and drew attention to the low quality of mathematics and science education in the public schools. As a response, Congress passed the National Defense Education Act in 1958 in an attempt to increase the number of science, mathematics, and foreign language majors. The New Math movement gained support in the 1960s due to these two events (Klein, 2003; Woodward, 2004).

The American Mathematical Society supported New Math through the School Mathematics Study Group, which consisted of mathematicians and high school mathematics teachers. Other contributors were the National Council of Teachers of Mathematics (NCTM), the
The New Math program had positive and negative effects. The positive impact was that calculus courses were introduced at the high school level, formal mathematics was emphasized, and more students were encouraged to take algebra and geometry. The New Math brought with it several negative side effects: minimal attention was paid to basic skills, New Math was considered abstract, teachers were not trained to teach the content, and many parents were unable to help their children learn it. Public criticism increased because students’ abilities to do basic math skills deteriorated (Klein, 2003; Woodward, 2004).

The 1970s brought a reaction to the changes that New Math had provided, resulting in a back-to-basics movement. This resembled the Progressive Movement of the 1920s. The purpose of back-to-basics was to encourage schools to focus on the basics of reading, writing, and arithmetic (Woodward, 2004). Back to basics also failed because schools had limited resources, and students had limited support at home, especially among low income groups. There was no opportunity for tutoring on basic skills outside of class. These limitations were reflected in low standardized test scores (Klein, 2003).

In response to this situation, the National Council of Teachers of Mathematics (NCTM), with support from the National Science Foundation (NSF), started a project called Priorities in School Mathematics (PRISM) in the mid-1970s to improve the condition of mathematics education. The NCTM addressed the crisis in mathematics education with its document, *An Agenda for Action: Recommendations for School Mathematics for the 1980s* (Grouws & Schultz, 1986).
An *Agenda for Action* recommended that problem solving be the focus of school mathematics in the 1980s, along with new ways of teaching. Other recommendations included incorporating technology at all grade levels, stating that the difficulty in paper and pencil calculation should not interfere with learning of problem-solving strategies, encouraging the use of manipulatives, promoting cooperative learning, administering multiple types of assessments, and adhering to specific standards in teaching, and integrating mathematics topics (Grouws & Schultz, 1986). Although this report was insightful, it received little attention because it was largely overshadowed by the report, *A Nation at Risk*.

The National Commission on Excellence in Education released the report *A Nation at Risk* in 1983. This report cautioned that educational foundations of society were being eroded by a rising tide of mediocrity that threatened the future of the nation and people. This report, considered an open letter to the American people, called for educators, parents, policymakers, and students to reform public school education, which was in need of urgent improvement (National Commission on Excellence in Education, 1983).

The data, findings, and recommendations of this commission were organized around four major topics: (a) content; (b) time; (c) teaching in English, mathematics, science, social studies; and (d) computer science. The recommendations for mathematics topics included students should be able to (a) understand geometric and algebraic concepts; (b) understand probability and statistics; (c) apply mathematics in everyday situations; and (d) estimate, approximate, measure, and test the accuracy of their evaluations. The commission further recommended equally demanding mathematics curricula for those students who did not plan to pursue a formal education. Other recommendations included that standardized tests be used for accountability,
that there be more courses in teacher training, that textbooks have more rigorous content, and
that attention be focused on the teacher shortage (National Commission on Excellence, 1983).

In 1986, the Board of Directors of NCTM also recognized a need for national standards
and professional organizations for K-12 educators to improve student achievement. Improvement
in mathematics education was necessitated by the needs of society to have a mathematically
literate workforce and an informed electorate, and to promote problem-solving skills for lifelong
learning with opportunities for advancement. So, NCTM established the Commission on
Standards for School Mathematics to improve the quality of mathematics education to meet the
growing needs of the workforce (Klein, 2003).

**Reform Documents**

Societal requirements motivated the development of the *Curriculum and Evaluation
Standards for School Mathematics* (NCTM, 1989); a document of major importance in
improving the quality of mathematics education in Grades K-12. This document contained a set
of standards for judging mathematics curricula and for evaluating the quality of curricula and
student achievement. Five general goals were outlined for all students by NCTM’s 1989
standards: (a) students learn to value mathematics, (b) students become confident in their ability
to do mathematics, (c) students become mathematical problem solvers, (d) students learn to
communicate mathematically, and (e) students learn to reason mathematically. In many respects,
the 1989 NCTM standards promoted the views of *An Agenda for Action*. The NCTM *Standards*
also advocated student-centered, discovery learning. Basic skills and general mathematical
concepts were to be learned through real world problems. Constructivism in learning
mathematics was promoted by NCTM through this and successive publications (NCTM, 1989).
In 1991, NCTM published the second standards document, *Professional Standards for Teaching Mathematics*. These standards were published to help improve the quality of school mathematics and helped NCTM state what its members value in curriculum, teaching, and assessment. These standards address professional mathematics teaching on the basis of two assumptions: first, teachers are the primary figures in changing the way mathematics is taught and learned in schools; and second, change requires that teachers have long-term support and adequate resources (NCTM, 1991). In 1992, the National Science Foundation (NSF) started funding the development of standards-aligned curricula. Consequently, many states developed and adopted curricula aligned with the standards (Woodward, 2004).

Following this, the third document, *Assessment Standards for School Mathematics*, was published in 1995 by NCTM as a means to help improve the quality of school mathematics. It was based on research and development related to national efforts to reform the teaching and learning of mathematics and included six assessment standards addressing mathematics, learning, equity, openness, inferences, and coherence (NCTM, 1995).

The NCTM publications faced criticism that there was no mention in the standards about how the proposed curriculum would affect special education students who were mostly receiving instruction in the general education classrooms. In addition, the standards were difficult to implement in classrooms due to limited resources (Woodward, 2004). Consequently, the NCTM standards were criticized as elitist, too difficult to implement, devoid of research foundation, and representative of discovery-oriented constructivism (Carnine, Jones, & Dixon, 1994; Hofmeister, 1993).

The varied criticisms of the NCTM standards paved the way for revising the standards to include more balance and clarity. In 2000, NCTM used a consensus process that involved
mathematicians, teachers, and researchers to revise the initial standards. Thus, *Principles and Standards for School Mathematics (PSSM; NCTM, 2000)* was published as a revision of the three previous documents.

The new standards were organized around six principles that help in rendering high-quality mathematics education; equity, curriculum, teaching, learning, assessment, and technology. The standards also include five content and process standards. The content standards are number and operations, geometry, measurement, data analysis, and probability. The content standards address the content all students should learn and be able to utilize. The process standards are problem solving, reasoning and proof, communication, connections, and representation. The content standards and process standards together aim to provide the mathematical skills and conceptual knowledge students will need in the 21st century (NCTM, 2000).

The purpose of *PSSM* is to establish a comprehensive and coherent set of goals for mathematics in Grades K-12. This vision assumes that students engage in complex learning tasks that draw on knowledge from a wide variety of mathematics topics; represent mathematics in a variety of ways; develop, refine, and test conjectures on the basis of evidence; develop flexible and resourceful problem-solving skills; work productively and reflectively alone or in groups, using the latest technology; and effectively communicate their ideas and results in a variety of ways (NCTM, 2000).

These goals will orient mathematics curricula, teaching, and assessment to the future. Moreover, *PSSM* will serve as a resource for teachers, education leaders, and policymakers. Also, *PSSM* will assist in the development of curriculum frameworks and instructional materials.
Finally, *PSSM* will stimulate ideas and ongoing conversations at national, state, and local levels about how best to help students gain a deeper understanding of mathematics (NCTM, 2000).

In 2006, NCTM released *Curriculum Focal Points* for preK-8. In the focal points, NCTM identified the most important mathematical topics for each grade level, including related ideas, concepts, skills, and procedures that form the foundation for learning. Further, NCTM stated that organizing the curriculum around the focal points with an emphasis on the *PSSM* process standards can provide students with a connected, coherent, expanded body of mathematical knowledge and ways of thinking (NCTM, 2006).

The NCTM publications, overall, have suggested curricula that require a shift in content and pedagogy from the traditional method of teaching to exploring concepts that promote mathematical thinking. They also recommended that students actively participate in the learning process. Additionally, *PSSM* advocates mathematical thinking through exploration, conjectures, and problem solving. Thus, NCTM highlighted and recommended a standards-based classroom that aligns with NCTM principles, content, and process standards (NCTM, 2000). During the time NCTM standards were being revised, student achievement was measured through various tests administered nationally and internationally in the U.S.

*National and International Assessments*

Since 1990, the Educational Testing Service has administered the National Assessment of Educational Progress (NAEP), also known as the Nation’s Report Card, and related projects. The NAEP is an ongoing, congressionally mandated project established to conduct national surveys of the educational attainments of students in the United States. Its primary goal is to determine and report the status of and trends over time in educational achievement across the nation. In the
NAEP assessment, the average mathematics scores increased 27 points out of 500 possible points for fourth graders and 19 points out of 500 possible points for eighth graders from 1990 to 2007. Such minimal increases in students’ performance nationwide over a span of 17 years cause concerns about the condition of mathematics education (NCES, 2007c).

Two major international evaluations of students’ mathematics and science achievement have been ongoing. The Trends in International Mathematics and Science Study (TIMSS) has been administered every 4 years to fourth- and eighth-grade students since 1995. The Program of International Assessment (PISA) has been administered to 15-year-old students every 3 years since 2000. The purpose of the TIMSS evaluations is to measure the mathematics and science knowledge and skills broadly aligned with curricula of different countries (NCES, 2004). The PISA evaluations measure reading, mathematics, and science literacy with one subject assessed in depth at each administration on a rotating basis and two other subjects as minor domains. The purpose of PISA evaluations is to measure how well students can apply their knowledge and skills to real-life contexts. In general, the TIMSS and PISA have reported low scores for U.S. students since 1995. The concern for educators is that although there has been improvement in overall students’ performance in mathematics, it has been marginal (NCES, 2004, 2006a, 2006b).

Another reason for concern about mathematics education was the result of the TIMSS in 1995. This was conducted with almost half a million fourth-grade, eighth-grade, and 12th-grade students from 41 countries. This assessment was aimed at measuring mathematics and science performance of content and skills internationally. The 1995 TIMSS results indicated that fourth-grade students outperformed their international peers; however, the results for eighth grade were
sliding down, and by 12th grade, students from the United States scored the lowest of the participating countries (NCES, 1998).

One of the findings of the TIMSS (1995) was that students fall short in their understanding of the nature of mathematics and their ability to apply their content knowledge to real-life situations, all of which called for improvement in school mathematics. The 1995 TIMSS evaluation overall indicated a weakness in U.S. students’ conceptual understanding and mathematical abilities (Gallagher, 1997; NCES, 1998). Four years later, the TIMSS was again administered. The term “Third” in 1995 in the TIMSS title changed to “Trends” in the following years 1999, 2003, and 2007. According to the TIMSS 2003 data, fourth and eighth graders performed above the international average in mathematics (Gonzales, Guzman, Partelow, Kastberg, & Williams, 2004).

In comparison with participating countries in 2003, U.S. fourth graders performed lower than 11 countries, and the eighth graders performed lower than 14 countries. According to the TIMSS 2007 data, U.S. fourth graders and eighth graders improved in mathematics. Compared with participating countries, U.S. fourth graders performed lower than their peers in eight countries, and eighth graders performed lower than peers in five countries (TIMSS, 2007). The TIMSS studies identified three overarching reasons for such results: (a) the U.S. lacks a coherent, nationally defined curriculum; (b) U.S. teachers emphasize how to solve the problems (procedures) rather than emphasizing the underlying mathematical principles; and (c) U.S. mathematics textbooks cover too many topics superficially and tend not to approach topics in depth. The rankings of U.S. students on the TIMSS results raised concerns about their performance in mathematics (TIMSS, 2007).
Another international assessment used to assess mathematics achievement was the Program for International Student Assessment (PISA), a system that measures 15-year-olds’ performance in reading literacy, science literacy, and mathematics literacy every 3 years. The PISA was first implemented in 2000 with 30 countries and is sponsored by the Organization for Economic Corporation and Development (OECD). In 2006, the number of participating countries increased to 57, including 30 OECD countries and 27 non-OECD countries. The United States is one of the OECD countries (NCES, 2007a).

On the 2006 PISA, the average score for U.S. 15-year-olds in mathematics literacy was 474, much lower than the PISA average of 498; the maximum possible score was 1000. Average mathematics literacy in the United States was lower than the average score in 23 of the other 29 OECD countries for which comparable PISA results were reported, higher than the average score in four other OECD countries, and not measurably different from the score of two other OECD countries. Comparable mathematics literacy results also were reported from 27 non-OECD countries, eight of which had higher scores than the United States. These results added to the concerns regarding the performance of U.S. students in mathematics (NCES, 2007a).

The OECD gives the following recommendations for improving students’ scores based on the practices of high achieving countries: (a) principals should be trained, empowered, and accountable and provide instructional leadership; (b) schools should attract, recruit, and provide training for prospective teachers from the top third of the graduation distribution; (c) schools should provide incentives and funding to encourage a fair distribution of teaching talent; (d) expectations of teachers should be clear, consistent quality in teaching, and professionalism; and (e) schools should offer ongoing professional development focused on classroom practice (OECD, 2006).
Collectively, mathematics achievement reported from TIMSS, PISA, and NAEP indicates that U.S. students need to improve mathematical literacy and achievement. Although some gains were seen from 1990 to 2007, they were not significant enough to show adequate progress. These reports make it evident that the United States has been unsuccessful in instilling in students the required mathematical skills to meet the demands of the 21st century. The major problem reported is low achievement scores in mathematics. Thus, U.S. students are not adequately prepared to meet the demands of the current workforce (NCES, 2007a).

The present workplace demands a high level of mathematical thinking and problem solving in all fields. Students must be prepared for problem solving in a variety of settings (Carpenter, Fennema, Franke, Levi, & Empson, 1999; NCTM, 2000; Pollack, 2000). One of the reasons for low achievement could be the traditional methods used to teach mathematics (Ball, Hill, & Bass, 2005). Another reason for low achievement is teachers’ lack of content knowledge and innovative methods for teaching mathematics (NCTM, 2000; Wallace & Kang, 2004). Thus, teachers’ content and pedagogical knowledge influence student achievement.

One of the widely offered explanations of why K-12 students do not learn mathematics is the inadequacy of their teacher’s knowledge of mathematics (Ball, 1991; Ball, Lubienski, & Mewborn, 2001; Clarke & Clarke, 2004). A positive correlation exists between teacher content knowledge and student achievement (Hill, Rowen, & Ball, 2005; Utley, Mosley, & Bryant, 2005; Wilkins & Brand, 2004), such that when teachers’ content knowledge is higher, student achievement is higher. Research supports the role of teachers’ content and pedagogical knowledge as important components of effective elementary school mathematics instruction (Hill & Ball, 2004).
Wenglinsky (2002) also found a positive correlation between student achievement and teacher content knowledge when he examined mathematics achievement levels for more than 7,000 eighth graders in the 1996 NAEP. He found that student achievement was influenced by teacher content knowledge. Similar findings have been reported by Ball and Bass (2000) while observing novice as well as veteran teachers. They noted that content knowledge had a positive effect on teaching quality.

Hill et al. (2005) found that student achievement and teachers’ mathematical content knowledge have a positive correlation. Data were collected from students and teachers in 115 schools from 2000 to 2003. Of these 115 schools, 89 were participating in Comprehensive School Reform Programs, and 26 used as the comparison group did not participate in any Comprehensive School Reform Program. Data were obtained for 1,190 first-grade students and 1,733 third-grade students. Student achievement data were measured by the CTB/McGraw Hill Terra Nova Complete Battery based on students’ grade level. Teachers’ content knowledge was measured on a test measuring mathematics knowledge for teaching for 700 first-grade teachers and third-grade teachers. The results indicated that students of teachers scoring higher on the content knowledge test achieved higher scores in mathematics in the year-end assessments.

Echoing the importance of content knowledge and student-centered ways of teaching mathematics, teachers’ content knowledge has been a premise of mathematics education through NCTM since 1989. The reform documents published by NCTM recommended new ways of teaching mathematics. These reforms also suggested that teachers should be prepared to develop fluency in basic computational skills, an understanding of mathematical concepts, and an understanding of problem solving using instructional approaches such as collaborative work and manipulatives (Gibson & Van Strat, 2001; Nicol, 2002).
The type of teaching envisioned in these standards is different from what many teachers have experienced as students. In a standards-based classroom, application becomes part of understanding mathematics and provides ways to utilize mathematics. The main goal is to establish a strong relationship between mathematics and its uses. The teacher in a standards-based classroom is expected to actively engage students and be a facilitator (NCTM, 2000). In spite of the recommendations of reform efforts, teachers lack the needed knowledge to successfully teach elementary mathematics in a standards-based classroom (Gess-Newsome, Southerland, Johnson, & Woodbury, 2003) and lack the level of conceptual understanding and pedagogical training necessary to teach students to learn this way. Moreover, it has been documented that elementary and middle school teachers lack the knowledge base necessary to facilitate lessons requiring deep levels of subject matter expertise (Ball, 2003; Kent, Pligge, & Spence, 2003; Ma, 1999).

In a survey of 6,000 teachers, it was noted that although the teachers believed in reform, they considered themselves less than adequately prepared to implement standards-based curricula (Kent et al., 2003; Weiss, 1997). However, when teachers are trained to teach standards-based curricula through professional development, they are more likely to implement it in their classrooms. The NSF (1997) funded professional development projects that emphasized improving teachers’ knowledge and capacity to use standards-based reform.

Research on the Effects of Reform Efforts

Commencing in 1990, NSF funded several mathematics projects at all levels of education, so that the new projects could have the necessary materials to facilitate implementing the NCTM standards. Additionally, NSF prioritized teachers’ content and pedagogical
knowledge and funded for such professional development. Since then, research has been ongoing regarding the use of standards-based mathematics and its effects on student learning despite the difficulties involved, such as access to schools, identifying comparable groups, and gaining information on measurable student performance (Hiebert, 1999; Schoenfeld, 2000; Usiskin 2001).

Studies have been conducted with a variety of populations by different researchers that have shown support for the use of standards-based methods of teaching (Fuson, Caroll, & Durek, 2000; Huffman, Thomas, & Lawrenz, 2008; Mullis et al., 2001; Post, Harwell, Davis, & Maeda, 2008; Riordian & Noyce, 2001). Huntley, Rasmussen, Villarubi, Sangtong, and Fey (2000) investigated the impact of the Core-Plus Mathematics Project (CPMP) with high school students on the growth of student understanding, skills, and problem solving in algebra. Results indicated that standards-based curriculum materials such as graphing calculators assisted in solving algebraic problems within applied contexts, increasing student achievement.

Similar findings have been reported while investigating the impact of elementary standards-based units by Fuson et al. (2000), in a quantitative study. They used two sets of studies, the first study with 392 second graders in 22 classes and the second with 620 third graders in 29 classes. The students’ progress was measured with NAEP scores. All of these students used Everyday Mathematics (EM) as their primary resource. The students from the first study were followed through their third grade and continued as participants who had one more year of EM. Results from both studies show student gains in NAEP assessment. The EM students scored as well or better than students studying from traditional materials on standard topics, including place value and computation. In addition, the EM group had the opportunity to study topics in depth, which was absent in the traditional group. Such opportunity was found to have
led to increased learning, and the EM group significantly outperformed students in the NAEP sample on geometry items.

The Third International Mathematics and Science Study-Repeat (TIMSS-R) conducted in 1999 gives additional support to standards-based teaching in middle grades (6-8). Two groups of students from Michigan participated in the TIMSS-R. The first group, the Michigan state sample, was randomly selected by the TIMSS researchers. The second group included students from an “invitational” group of schools that used standards-based methods of teaching. Although the Michigan state sample was the highest performing state group of the 12 participating states in TIMSS-R, with an average score of 517 out of a possible 600 points, the Michigan invitational group performed significantly higher (532) than the Michigan state sample, indicating positive effects of standards-based reform efforts within these schools (Mullis et al., 2001).

Improvements in student achievement also were seen in a study conducted by Riordian and Noyce (2001) with approximately 7,000 students in fourth and eighth grades in Massachusetts. Sixty-seven schools from fourth grade and 21 schools from eighth grade participated in the study. Fourth-grade classes used Everyday Mathematics (EM), and eighth-grade classes used Connected Mathematics (CM). Of the 67 fourth-grade schools, 48 had implemented the program for 4 or more years (Group I) and the remaining 19 schools implemented the program for 2 or 3 years (Group II). Of the 21 middle schools using Connected Mathematics, one school had implemented it for 4 years (Group I), and the remaining 20 schools had used the program between 2 and 3 years (Group II). Four comparison groups were selected in Massachusetts to match these four target groups; however, the comparison group did not use any standards-based teaching. All four groups were assessed on the Massachusetts Educational Assessment Program (MAEP) and Massachusetts Comprehensive Assessment System (MCAS).
Students using $EM$ curricula outscored their counterparts. The results showed that students in the target curriculum who had been using $EM$ or $CM$ longer (Group I schools) outscored their matched counterparts. The longer the implementation of the standards-based program in the school, the greater the correlation with a higher score for the students. The positive impact of the standards-based programs on student performance was consistent across students of different gender, race, and economic status. It was concluded that implementing standards-based teaching can improve student learning (Riordian & Noyce, 2001).

More recently, Post et al. (2008) conducted a study with approximately 1,400 middle-grade students who either used Connected Mathematics or Math Thematics for at least 3 years. These students were assessed on the Stanford Achievement Test and the New Standards Reference Exam in Mathematics. When the standards-based students’ achievement patterns were analyzed, their achievement was greater in open-ended and problem solving subtests than in procedures subtests. This finding is consistent with the results reported about standards-based mathematics improving conceptual knowledge (Senk & Thompson, 2003).

Research also documents the challenges in implementing standards-based mathematics (Ball, 1996; Clarke, 1995; Henningsen & Stein, 1997; Tetley, 1998), including teaching unfamiliar content, the teacher playing multiple roles, teacher lacking time for implementation, and the teacher needing to use new assessment tools. These factors individually and collectively influence the implementation of the standards-based mathematics curricula.

The research on achievement in mathematics for K-12 students has shown that students in the United States are not as competent as their peers in other countries tested by various large scale assessments. Similar conditions also exist in science education.
Elementary Science Education

History of Science Education

Since the launching of Sputnik in 1957, the science education community has been interested in improving knowledge of science in society. One reason was that not being competent globally in scientific knowledge posed threats to national security. In 1960, the National Society of Education focused on science education in the book *Rethinking Science Education*. In this book, it was proposed that science educators would produce citizens who understood science (DeBoer, 2000).

The National Science Teachers Association ([NSTA], 1971) identified scientific literacy as the most important goal of science education. According to this association, a scientifically literate person was one who uses science concepts, process skills, and values in making everyday decisions and understands the relationships between science, technology, and other facets of society (NSTA). In the 1970s and early 1980s, scientific literacy was strongly identified with science in its social context. Also, there was a debate among scientists as to whether science education was about the content of science or the science based on social issues (De Boer, 2000).

In 1983, the National Commission on Excellence in Education (NCES, 1983) issued the report *A Nation at Risk*. This report stated that the poor academic performance of U.S. students was the cause of its declining economic position in the world. The major concern of this report was that academic standards had fallen in the United States, as indicated by the low test scores of U.S. students, especially in mathematics and science, which called for improvements in science education (NCES). The recommendation was to create a more rigorous academic curriculum for all students built around the basic academic subjects of English, mathematics, science, and social studies.
The recommended measures for improvement in science education were that science teaching should provide students with (a) concepts, laws, and processes of physical and biological sciences; (b) the methods of reasoning; (c) the application of scientific knowledge to everyday life; and (d) the social and environmental implications of scientific and technological development. In order to address the rising concern of preparing the workforce needed for the 21st century, the report also suggested that science courses must be revised and updated (NCES).

In the late 1980s, research organizations such as American Association for the Advancement of Sciences (AAAS) and the National Research Council (NRC) also addressed the condition of science education. As a result, in 1990 the AAAS published its report, *Project 2061: Science for All Americans*. The purpose of the report was to clarify the goals of science education and start the process of reforming science education in a comprehensive manner. The report recommended addressing the basic dimensions of scientific literacy: (a) being familiar with the natural while recognizing its unity and diversity; (b) understanding the key concepts and principles of science; (c) being aware of how science, mathematics, and technology are interdependent; (d) developing scientific ways of thinking; and (e) using scientific knowledge and ways of thinking for individual and social processes (AAAS, 1990).

During this time, the National Assessment of Education Progress (NAEP) started to measure the national progress of fourth-grade and eighth-grade students. NAEP reported low scores in science for fourth- and eighth-grade students in 1990. Following this assessment, AAAS published *Benchmarks for Scientific Literacy* in 1993, an accompaniment to their previous report (Project 2061). The purpose of this document was to outline a long-term timeline of expected improvement in science education. *Benchmarks for Science Literacy* is the Project 2061 statement of what all students should know and be able to do in science and technology by
the end of Grades 2, 5, 8, and 12. The recommendations suggested at each grade level aim at reasonable progress towards the adult science literacy goals as spelled out in the report *Science for All Americans*. *Benchmarks* can help educators decide what to include or exclude in a core curriculum, when to teach, and why.

In the meantime, international assessments in science started. The findings from such assessments also added to the existing concerns for improvement in science. The Third International Mathematics and Science Study (TIMSS, 1995) was a comprehensive, international comparison of mathematics and science achievement conducted among 41 countries, including the United States. The 1995 TIMSS assessment revealed that U.S fourth graders performed above the international average in science, eighth graders performed at the international average in science, and 12th graders performed below the international average in science and scored among the lowest of the participating countries (National Center for Education Statistics, 1998). Since 1995, the TIMSS is administered every 4 years; however, the word “Third” has been replaced with “Trends” since 1999.

Following the two publications by AAAS and the TIMSS 1995 report, in 1996 the National Research Council released the *National Science Education Standards* (NSES). This was aimed at providing a direction for attaining scientific literacy in the United States, including excellence and equity in science education through content standards. These standards are as follows: (a) everyone should use scientific information to make choices; (b) everyone should be able to engage in discourse about important issues that involve science and technology; (c) everyone deserves to share the excitement and personal fulfillment that come from learning the natural world; (d) everyone should have an understanding of science that contributes in an essential way to these skills, because more jobs demand more skills requiring people to learn,
reason, think creatively, make decisions, and solve problems; and (e) everyone in the United States needs to have an equally capable citizenry to keep pace in global market (NRC, 1996).

Together, *Science for All Americans* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the *National Science Education Standards* (NRC, 1996) called for a shift in scientific literacy. Collectively, they recommended learning fewer topics in depth and advocated learning that promotes conceptual understanding of processes that help students make connections (NRC, 2000). Although none of these publications is a specific curriculum, they reinforce the need for designing instruction connected to real-life situations that promotes scientific literacy. They also recommend that students construct their own understanding of the world through inquiry-based learning (AAAS, 1990; NRC, 2000; NSTA, 1998).

Although research organizations were developing measures and giving direction to improve science education in the United States, U.S. students’ performance in science also was being measured nationally by the National Assessment of Education Progress (NAEP) since 1990. Students’ performance internationally has been assessed by TIMSS every 4 years since 1995 and by the Program for International Assessment (PISA) every 3 years since 2000 (NCES, 2001).

The NAEP 2006 results indicate that many U.S. students scored at the basic level on the science exam. At Grade 4, the average science score was higher in 2006 than in previous assessments; however, minimal gains have been reported. At Grade 8, the average science score in 2006 remained static compared to previous assessments. However, at Grade 12, the average science scores were lower than the assessment in 1996 and showed no significant change from 2000 (NCES, 2007a).
Comparisons of science achievement of fourth-grade and eighth-grade students are made for the 16 countries and 19 countries that collected data for 1995 and 2007, respectively, in TIMSS. Neither U.S. fourth nor eighth graders showed any detectable change in science achievement in 2007 compared to 1995. There was minimal increase in the average science achievement of fourth graders by three points and eighth graders by seven points in a span of 12 years. A lower percentage (4%) of U.S. fourth graders performed at or above the international benchmark in 2007 than in 1995. At Grade 8, there was a lower percentage (2%) of U.S. students who performed at or above the advanced international benchmark in science in 2007 than in 1999 (TIMSS, 2007).

In addition to TIMSS, the Organization for Economic Corporation and Development (OECD), an international organization of 30 industrialized countries, developed a second international assessment to determine students’ achievement in reading, mathematics, and science literacy in 2000 (Lemke et al., 2001). The results of the 2000 PISA indicated that U.S. 15 year-olds performed above average on scientific literacy, outperforming seven countries while scoring significantly lower than Australia, Finland, Japan, Canada, and Korea (NCES, 2001).

In 2006, 30 OECD countries and 27 non-OECD countries participated in PISA; with the United States among the OECD countries. In science literacy, the average score of U.S. 15-year-olds was lower than the average score of 16 OECD countries, higher than the scores of five OECD countries, and not measurably different from the average score in eight of the OECD countries (NCES, 2007a).

Collectively, the TIMSS, PISA, and NAEP data suggest that the longer U.S. students receive formal science education, the more poorly they perform on international as well as national assessments (Bybee, 2001). These published national and international reports
demonstrated a disconnect between what we want our students to know and what understandings the students are leaving the science classroom with, that are leading to low achievement in science.

**Possible Reasons for Low Achievement**

Although many factors may contribute to low achievement scores in science, the main reasons are cited lack of time, inadequate teacher training, and lack of content and pedagogical content knowledge among elementary teachers (Craig, 2006; Darling-Hammond, 2009). Goals in science curriculum can be achieved only with effective and qualified teachers in all classrooms (AAAS, 1990); and one of the strongest predictors of students’ success is the quality of teachers (Kreuger & Sutton, 2001).

A nationwide study conducted by the Bayer Corporation (2004) indicated that one of the reasons the quality of science teaching at K-5 levels in the United States was not satisfactory was lack of time. In this study, it was found that about 30% of the teachers reported that they taught science twice a week or less. The curriculum time devoted to science was much lower compared to English (95%) and mathematics (93%), because these subjects are taught every day. Supporting studies by Dickinson, Burns, Hagen, and Locker (1997) indicated that other subjects had curricular priorities over science, and the majority of elementary schools do not teach science throughout the year. Similar views were expressed by Goldston (2005), who contended that because science teachers at all grade levels are in a position to improve reading, writing, and mathematical skills, science class time, particularly in elementary grades, has been minimized, and in some instances science is not taught.
Consistent with the previously mentioned surveys, Horizon Research (2002) reported that less time is spent on elementary science every day, and of the time spent, most is allotted to traditional methods of teaching such as lectures and worksheets. The average K-5 teacher spends approximately 80 minutes per week in science instruction. This is far less than the recommended 300 minutes necessary to promote scientific literacy (Loucks-Horsley et al., 1998). In addition to the limited time devoted to teaching science, another problem faced by elementary teachers is inadequate training to teach reform-based science (Washor & Majowski, 2006).

Jeanpierre, Oberhauser, and Freeman (2005) conducted a study with 20 elementary science teachers to identify the effects of training on inquiry learning and how they implemented it in their classrooms. The participants were trained on teaching development of monarch butterfly projects. Field notes on conversations, classroom units, and interviews with participants were collected during and after the training sessions. The researchers and project staff evaluated the quality of the monarch butterfly projects completed during the training. After completing the training, the teachers taught the unit in their classes. Classroom observations of teaching were done before and after the training to study the impact of the training. Results indicated that almost half of the participants were not using the training in their classrooms before the study, and one fourth of the teachers were not using the training afterward. The teachers who used inquiry methods of teaching this unit before the training continued to do so after the training. The researchers concluded that more training was needed for the teachers to implement such inquiry-based units in their classrooms.

Further findings from science education indicate that the quality of science teaching at the elementary level is posing problems due to lack of teachers’ training. Although the elementary school years are the critical time for developing students’ interests in science,
exposure to science at this level was found to be low. In addition, elementary science teachers have been found to favor instruction that is teacher directed and they rely on textbooks due to lack of training in how to teach science effectively (Johnson, Kahle, & Fargo, 2006).

Often, elementary school teachers are less than adequately prepared in science content knowledge. According to the 2000 National Survey of Mathematics and Science Education, only 31% of K-3 teachers and 42% of Grades 4-6 teachers have taken at least one course in biology, physics, and earth science (Horizon Research, 2002). Also, less than 4% of elementary school teachers have an undergraduate degree either in science or science education (Loucks-Horsley et al., 1998). Due to this lack of preparation to teach science, 7 out of 10 teachers report that they do not feel well-prepared to teach science (Fulp, 2002).

As a result of lack of training and a general discomfort with teaching science, elementary teachers tend to teach less science, and of the science taught, more attention is given to life science than to physical science. Teachers rely on ready-made lessons and use an expository form of teaching. Such teaching is not in accord with the recommendations of either AAAS or NRC for promoting scientific literacy (Fishman, Marx, Best, & Tal, 2004; Harlen, 1997). One reason teachers do not adhere to the recommendations of research organizations for teaching science is their lack of content knowledge in science, and lack of pedagogical content knowledge can also be a problem contributing to students’ low achievement scores.

Ackerson (2005) conducted a qualitative study with two elementary science teachers who taught astronomy units. Data were collected through observation, field notes, and interviews with the teachers. The findings indicated that the two teachers had designed their units and focused on discussion ideas instead of following a set lesson plan. The teachers paid attention to students’ questions about astronomy and invested time in finding details to answer the questions posed by
their students. They used trade books to explain the concepts. Although the teachers tried their best to teach the astronomy units, they considered that their lack of knowledge of astronomy was a factor preventing them from teaching the concepts effectively. The study concluded that improving content knowledge can improve the quality of teaching.

In addition to a lack of science content preparation, elementary teachers face difficulties teaching inquiry-based science. Because most elementary teachers learn science content when they learn how to teach science in the methods courses in teacher education, they are not specialists in science and have misconceptions (Davis, 2004; Longerman, 2000). Thus, their content knowledge is insufficient. This insufficient content knowledge can create lack of confidence in teaching inquiry-based science (Borko, 1993).

A qualitative study by Schwartz and Lederman (2002) gave insights into two elementary science teachers and how their content knowledge in science affected teaching. Data were collected through observation and interviews. One of the teachers had more science background (content) than the other. The latter was able to use his knowledge while teaching the nature of science and used scientific methods in teaching, whereas the former, with less content knowledge, was intimidated with his lack of knowledge while teaching the nature of science and therefore embraced traditional methods of teaching science. The study concluded that teachers’ content knowledge and pedagogical content knowledge can be improved through exposing teachers to professional development with content area as the focus.

Inquiry-based Teaching and Learning

Contemporary science education must take into account research on reform efforts, assessment, student learning, and inquiry-based instruction. Science teachers must develop an
understanding of all of these and use them in their classroom practice (NRC, 2000). Inquiry involves students in the process of solving scientific problems by asking questions, designing investigations, collecting, organizing, and analyzing data, and finally sharing the results (Colburn, 2007; Llewellyn, 2005; NRC 2000; Zion & Sadah 2007). Through this process students could become experts in the subject.

According to the National Research Council, inquiry is a flexible process that mirrors the way in which scientists study the natural world, propose explanations, and revise scientific knowledge with active student participation. Engaging K-12 students in inquiry-based learning is the cornerstone of ongoing science education reforms (AAAS, 1993; NRC, 1996, 2000).

Inquiry-based teaching helps students learn science content, master how to do science, understand the nature of science, and it acts as a means to improve students’ critical thinking and reasoning skills while engaging them in science classroom and laboratories (Colburn, 2007; Olson & Loucks-Horsley, 2000; Ross, 1998; & Zion, Cohen, & Amir, 2007). Thus inquiry-based learning promotes analytical thinking skills based on observations and collected data and has been the premise of science education. Therefore researchers encourage teachers to implement inquiry-based learning in their classrooms.

Colburn (2007) and Zion and Sadah (2007) advocated that science teachers promote the use of inquiry-based learning in order to demonstrate to their students the learning process and to develop their natural curiosity. Inquiry-based learning has a theoretical basis in constructivism because students construct knowledge through problem-solving based on information gained during experimentation (Krajcik, Marx, Blumenfeld, Soloway, & Fishman, 2000). Finally, inquiry-based learning can shift the nature of learning from memorizing facts to a multisensory learning experience (Heddens, 1997).
Research on the Effects of Reform Efforts

Science education standards established by AAAS and NRC put less emphasis on memorizing scientific facts and more emphasis on students investigating and developing deep understanding from their inquiries. Support for inquiry-based science has been documented by numerous research studies (Amaral, Garrison, & Klentschy, 2000; Hunt, 1999; Rivet & Krajcik, 2004).

A quantitative study was conducted by Hunt (1999) with 24,599 middle grade students from 1,052 schools (815 public and 237 private schools) to see if the frequency of using inquiry-based teaching impacted student achievement. Students were categorized into five groups. The groups were based on the amount of inquiry-based teaching. These groups had inquiry-based teaching (a) every day, (b) once a week, (c) once a month, (d) less than once a month, or (e) never. A cognitive test battery developed by the Educational Testing Service was used to measure student achievement. The science component of this battery consisted of 25 multiple-choice items designed to assess science knowledge and scientific reasoning ability. Information regarding the frequency of inquiry-based teaching was collected through a self-administered questionnaire that included specific questions related to the type of teaching. Results indicated that students who had inquiry-based teaching either every day or once a week scored significantly higher than students who had inquiry-based teaching once a month, less than once a month, or never. It was concluded that the frequency of using inquiry-based teaching can show gains on standardized tests. In addition, the duration of implementing inquiry-based teaching also can make a difference in student achievement.

In another study, the Valle Imperial Project (VIPS) in Science (Klentschy et al., 2000) in California supported that the longer schools used inquiry-based teaching, the better the results in
student achievement. This 4-year project began in 1995 serving 22,500 K-6 students in 14 school
districts. Of those 14 school districts, one district was selected to measure the impact of the VIPS
program. The selected district was the largest, consisting of 6,500 students. Five elements guided
this program: (a) inquiry-based teaching, (b) sustained professional development, (c) materials
support, (d) administrative support, and (e) assessment. Students were exposed to four modules
per year, with the topics drawn from life, physical, and earth science. Teachers received 100
hours of professional development to strengthen their content knowledge and were provided with
necessary materials to teach. Student achievement was measured with the Science Subtest of
Stanford Achievement Test; however, it was construed to present the philosophy mirrored in
Science for All Americans. In 1999, after 4 years of implementing inquiry-based instruction
combined with intense professional development, results indicated that the longer students were
involved in the inquiry-based program the higher the science achievement scores were.

Another study concerning inquiry-based teaching was conducted by Rivet and Krajcik
(2004) with 24 teachers and 2,500 sixth-grade students at 15 different public schools in Detroit.
This longitudinal study was conducted for a span of 4 years (1999-2002) to determine whether
student learning in science achievement improved when inquiry-based teaching was used in
schools. Students worked on a project investigating how machines help build big things, which
addressed the science goals of balanced and unbalanced forces, and simple and complex
machines. The project took 8-10 weeks, and students worked in collaborative groups to design
and explore how they could change a simple machine to increase its mechanical advantage.
Achievement outcomes as measured by the pre/posttest showed significant and consistently high
learning gains.
All students participating in this project were assessed by identical pre-and posttest measures before and at the conclusion of the project. The pre- and posttest measures consisted of 18 multiple-choice items and two short response items, with a maximum score of 24 points. Test items were created to measure content and process standards and also addressed student understanding of inquiry process skills, including conducting investigations, interpreting graphs, and writing conclusions supported by evidence. Matched two-tailed $t$ test analyses were conducted to compare the pre- and posttest results after each year of the project. Results indicated that students consistently showed significant overall improvement on the pre-and posttest measure for Big Things during the 4 years of enactment of this project. These results support the idea that inquiry-based teaching improves student achievement. Teaching inquiry-based science, however, requires a shift in the manner of teaching science because it is different from the traditional methods (Rivet & Krajcik, 2004).

Problems in Teaching Inquiry-based Science

Recent inquiry-based approaches to instruction present challenges to both teachers and students. Although research on the benefits of inquiry-based teaching have been documented, many science teachers continue using the traditional methods of teaching science (Ackerson 2005; NRC, 1999; Tobin & Garnett, 1998). For teachers using the traditional methods of teaching, inquiry teaching challenges them to develop new content knowledge, pedagogical techniques, and approaches to assessment and classroom management (Hancock, Kaput, & Goldsmith, 1992; Marx, Blumenfeld, Krajcik, & Soloway, 1997).

Research identifies three main reasons for teachers’ inconsistency with reform-based methods of teaching science: inadequacy of time, lack of teaching resources, and lack of content
and pedagogical knowledge (Darling-Hammond, 2003; Guskey, 1999; Llewellyn, 2005). Students cannot achieve scientific literacy if their teachers are not skilled in the process of teaching science or if the teachers are not familiar with the concepts being taught (Darling-Hammond, 2009; Tobin & Garnett, 1998). Thus, teachers need training to implement new methods of teaching science.

In a case study conducted by Kelly and Staver (2005) to identify the impact of adopting an inquiry-based, K-6 science curriculum in a Midwestern school, quantitative and qualitative data were collected. The study found that although teachers had all the supplies needed, many K-6 teachers remained uncomfortable teaching science. It further found that teachers’ attitudes about the new science program were positive. Teachers struggled with science-as-inquiry because there were many new concepts; however, students learned more and were involved in inquiry learning. This study concluded that a systemic, ongoing program of professional development is necessary to address teachers’ concerns about obtaining fluency in science concepts.

Other difficulties include pressure to cover more content and maintain equity in teaching science for all students, the teachers’ lack of empowerment, and the absence of effective professional development (Anderson & Helms, 2001; Darling-Hammond, 2003). Teachers also struggle to balance implementing inquiry-based learning and preparing students for the standardized tests. For successful implementation of inquiry science, teachers must be well trained in methods of teaching and content knowledge (NCES, 2007c).

A qualitative case study of two exemplary elementary science teachers was conducted by Harris (2008) to determine the effects of local and national curricular mandates on everyday science instruction. This study was centered on the evolution of reform initiatives and how the
initiatives impact teaching science. Reform initiatives discussed in this research were the Alabama Reading Initiative and the Alabama State Department of Education’s mandated testing and monitoring progress of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) and how these reforms impacted daily science teaching. Data sources were classroom observations, semi-structured interviews, and artifacts. The research findings indicate the study’s participants had students as their focus and they made decisions from their teacher knowledge bases to adapt, negotiate, or resist curricular mandates to teach science and meet the needs of their students in the classroom.

To summarize, inquiry-based teaching in mathematics and science requires teachers to have mastery of content and to be able to implement new ways of teaching mathematics (Loucks-Horsley et al., 1998). Such teaching requires teachers to have mastery of content and effective ways of teaching (Ma, 1999). Further, it requires teachers to make adaptations within the stipulated time to teach science and this requires finding a balance between what to implement and what to forego to satisfy the administration and consider the best interests of the students. Making such compromises require a shift in the ways of teaching. Professional development is considered an essential mechanism to help make this shift as well as improve teachers’ content knowledge and teaching practices (Desimone et al., 2002). Effective professional development plays an important role in improving teachers’ knowledge.

Professional Development

Professional development has been defined as a process through which staff methodologies and competencies are improved to promote student success (Hassell, 1999); a deliberate attempt to improve teacher learning and student achievement (Vontz & Lemig, 2006);
and as a comprehensive, sustained, and intensive approach to improving teachers’ and principals’ effectiveness in raising student achievement (National Staff Development Council, 2007). Professional development has been defined in various ways, although the common aim is improving knowledge for teaching and student achievement. Furthermore, professional development is one of the recommendations made by NCTM (1989) and NRC (1996) to improve mathematical and scientific literacy for all students.

Policy documents indicate that professional development models should use reform-based practices to achieve mathematical and scientific literacy for all. However, a gap between ideal and actual professional practice of effective professional development exists (Loucks-Horsley et al., 2003). This divide in professional development models has sparked various researchers to establish the traits of effective professional development.

**Characteristics of Effective Professional Development Programs**

Research and policy have established what could constitute effective professional development based on the needs of teachers and student achievement with Guskey (2003), Darling-Hammond (2009), Loucks-Horsley et al. (2003), and Thompson and Zeuli (1999) reaching a consensus concerning the key elements of effective professional development.

After reviewing various lists of characteristics of effective professional development published by research and policy organizations, such as the Association for Supervision and Curriculum Development, Educational Research Service, and Eisenhower Professional Development Program, Guskey (2003) identified the attributes of an effective professional development program: (a) enhancing teachers’ content and pedagogical knowledge, (b) providing sufficient time and resources, (c) promoting collaborative learning, (d) establishing
procedures for evaluating the professional development experience, and (e) conducting school or site-based professional development. These essential qualities of professional development also have been supported by other researchers (Cohen & Hill, 2001; Garet et al., 2008; Knapp, 2003; Perez et al., 2008; Weiss & Pasley, 2006; Yoon, Duncan, Lee, Scarlos, & Shapley, 2007).

Loucks-Horsley et al (2003) added three additional traits of effective professional development for science and mathematics teachers: (a) establishing a well-defined image of the classroom learning and teaching, (b) creating a professional development that engages teachers as adult learners, and (c) developing a support system for teachers so that they can serve leadership roles in their schools. These traits concur with the views held by Darling-Hammond (2009).

Thompson and Zeuli (1999) asserted that professional development participants must experience a certain amount of controversy in their existing beliefs, knowledge, and experiences with teaching and learning. For this to occur, the professional development program should include the following characteristics: (a) the experiences provided should generate cognitive dissonance between teachers’ existing beliefs and practices that promote student learning, (b) time and support should be provided to teachers to resolve the cognitive dissonance through reflective journals and stimulating discussions, (c) opportunities should be provided for teachers to be engaged with the learning experience their students will be having such that teachers become learners, (d) a variety of strategies should be provided that are parallel to their new understandings of student learning, and (e) assistance should be given in translating new understandings into practice. Effective transformative learning must be professional and personal. Such experience can help teachers to have a transformative learning experience.
Two additional characteristics of effective professional development are discussed across literature: (a) active, intensive, and sustained professional development with an extended time (Darling-Hammond, 2009; Yoon et al., 2007), and (b) the need for sustained support for teachers as they return to their schools to implement the professional development objectives (Desimone et al., 2002; Guskey, 2003; Loucks-Horsley et al., 2003). Moreover, classroom change depends on providing extended support throughout the school year with opportunities for teachers to collaborate and reflect on their practices (Borasi & Fonzi, 2002).

The design of professional development must address how teachers learn. Snow-Renner and Lauer (2005) stated that active learning opportunities and reflection on teaching practices allow teachers to transform their teaching instead of layering new strategies over the old ones. Such professional development models provide opportunities for modeling, constructing, and reflecting on strategies (Garet, Porter, Desimone, Birman & Yoon, 2001; Saxe, Gearhart, & Nasir, 2000; Suppovitz & Turner, 2000).

Cohen and Hill (2001) described two approaches that proved successful in California’s statewide reform, which introduced a new mathematics curriculum and assessments. Both approaches provided opportunities for teachers to actively learn about new mathematics content and also to practice and share their knowledge. The first approach was split into two phases. During the first phase, teachers learned how to teach the new reform mathematics curriculum. Then, they taught in their classrooms. During the second phase, the teachers returned to share their experiences with other teachers to problem solve as part of getting prepared to teach the following units. In the second approach, teachers evaluated student work directly related to the new reform mathematics. During this time, teachers were guided through problems they typically face in the classroom, and teachers learned how to be proactive and address such
misunderstandings. The study reiterates that teachers’ active participation in professional development is beneficial to the teachers and students alike.

In addition, teaching practices and student learning are more likely to be transformed by professional development that is sustained, coherent, and intense (Suppovitz, Mayer, & Kahle, 2000; Weiss & Pasley, 2006). The traditional episodic, fragmented approach does not allow for rigorous, cumulative learning (Knapp, 2003). Two separate evaluations found that teachers who had 80 or more hours of professional development in inquiry-based science the previous year were significantly more likely to use this type of science instruction than those who had experienced fewer hours (Suppovitz & Turner, 2000).

In a review of nine studies, Yoon et al. (2007) found that sustained and intensive professional development was positively related to student achievement. The three studies of professional development that lasted for 14 hours or less showed no effect on student learning. Studies of programs offering more than 14 hours of sustained teacher learning, however, showed minimal increase in student learning and the largest gains effects were found in programs offering professional development between 30 and 100 hours spread out over 6 to 12 months.

Incorporating what teachers consider as effective in professional development is important. A study conducted by Rogers (2006) compared the views of teachers and professional development facilitators concerning effective professional development. Seventy-two K-12 teachers (of those 36 were elementary) and 23 professional development facilitators constituted the participants. They were in nine science and mathematics professional development projects. The teachers’ themes for characterizing effective professional development included classroom application, teacher as learner, and teacher networking. The professional development facilitators also had classroom application, teachers as learners, and developing collegial relationships
among teachers to improve knowledge as themes of effective professional development. The study concluded that such useful professional development programs were likely to be implemented in the classrooms.

A 3-year longitudinal study by Desimone et al. (2002), with a sample of 207 K-12 teachers in 30 schools from five different states, showed that professional development on specific instructional practices increased teachers’ implementation in the classroom. It was also noted that features such as active learning opportunities increased the effect of professional development on teachers’ instruction. Active engagement of teachers during professional development also has been recommended by Darling-Hammond (2009) and Loucks-Horsley et al. (1998).

**The Effects of Successful Professional Development Programs on Student Achievement**

Students of mathematics and science teachers who participate in professional development activities designed to increase the use of standards-based instructional practices demonstrate increased achievement (Marx et al., 2004). Marx et al.’s longitudinal study was conducted in Michigan for 4 years (1998-2001). The participants were approximately 8,000 students in Grades 6 to 8 and 102 of their teachers. The effects of implementing an inquiry-based science curriculum called Learning Technologies in Urban Schools (LeTUS) developed as a National Science Foundation collaborative project with Detroit Public Schools. The effect of this study was measured through the intensity of teacher professional development and student achievement results from curriculum-based tests.

A wide range of systemic issues such as curriculum design, development and enactment, teacher professional development, and sustained support to implement the program were the foci
for this collaborative project. Teachers were provided multiple opportunities to participate in a variety of LeTUS professional development settings during each year. These included one summer institute which lasted for a week and engaged teachers with learning about inquiry teaching. Also it incorporated new educational technologies, fostered collaboration, and provided project-specific instruction that addressed the learning goals, context, main activities, and assessment for the LeTUS project. Saturday workshops also were provided once a month. These workshops consisted of two parts. The first part was project-specific group work where teachers focused on specific content ideas, and the second part was cross-project, which focused on specific aspects of inquiry-based teaching.

Over the 4 years of the study, participating teachers received 130 hours of subject-specific sustained professional development. To assess student understanding of science content and process skills, curriculum-based written assessments were developed and administered to all participating students at the beginning and end of each unit. Curriculum materials were revised every year after examining students’ results. Thus, the gains in student learning were the result of two factors: materials used to teach and the way content was taught. The results indicate statistically significant increases in curriculum-based test scores for each year of participation. The strength of the effects grew over the increasing effect size estimates across the years. The findings indicate that students can succeed in inquiry-based learning when teachers have sustained professional development and have received continuous support to implement the new curriculum. Rivet and Krajcik (2004) analyzed the data of the sixth-grade students (2,500) and their 24 teachers of the same study. They considered that the professional development provided to teachers was one of the contributing factors to increased student achievement.
In order to obtain significant improvements in student learning, change must be established at the school level. More recently, a 3-year longitudinal study was conducted by Johnson et al. (2006) with 17 science teachers from Grades 6 to 8 in two different schools in Ohio to see the effect of whole school participation in professional development and student achievement in science. Eleven science teachers and 750 students from Glendale Middle School constituted the population of the experimental group, where the teachers were involved in the Discovery Model Initiative. The control group population consisted of six science teachers and 900 students from Central Middle School; however, the control group teachers were not involved in the program.

The Discovery Model Initiative team from Glendale Middle School attended a 2-week intensive seminar institute. The summer institute was held at a local university with a science education faculty as coach. In year one at the Discovery Model School Initiative, science teachers learned about inquiry-based teaching in collaborative grades on their specific grade level. After this, the lessons were implemented in classrooms and teachers returned back to their groups to discuss what has to be revised for the following year. In year two, the teachers’ professional development focused on aligning their instruction to Ohio’s science content standards. During Year three, the focus was on assessments of inquiry-based teaching (Johnson et al., 2006).

Students from both groups were closely matched except for the variable of teachers having professional development. Both sets of students were assessed using the Inquiry Test in Science all 3 years. During the first year of study, students from Glendale Middle School and Central Middle School scored similarly on the Discovery Inquiry Test (DIT). In the second and third year, significant changes in student achievement were seen. By the end of year two, Glendale teachers had completed 100 hours of professional development in subject specific areas.
and student performance on DIT improved every year. The results of this quasi-experimental study indicate a relationship between whole-school, sustained, content-focused professional development and student achievement. Further findings from this study add to the current knowledge that professional development experiences, focused in increasing content knowledge, and use of inquiry-based teaching practices increases student achievement (Johnson et al., 2006).

A study conducted by Lee, Deaktor, and Lambert (2008) emphasized the importance of content-focused professional development and its effects on student achievement in science. This quantitative longitudinal study examined the impact of a 3-year implementation of a professional development intervention with grade specific content focus. The study involved 574 third-grade students, 688 fourth-grade students, and 431 fifth-grade students at six elementary schools in a large urban school district during the years 2001-2004. The study sample included 22 third-grade teachers, 22 fourth-grade teachers, and 12 fifth-grade teachers. Teachers attended four full-day workshops on regular school days during each year of this intervention. Separate workshops were conducted for teachers at each grade level, allowing them to focus on specific issues pertaining to instructional units for their specific grades. In determining the impact of intervention, the study examined (a) overall science achievement in pre- and posttest scores of science units, and (b) comparison with national (NAEP) science and international (TIMSS) samples. Students at all three grade levels demonstrated statistically significant gains and large effect magnitudes at the end of each school year. The third-grade students showed the most achievement gains on unit tests and NAEP/TIMSS tests. The outcomes of the study indicate the effectiveness of content-based professional development and the cumulative effects of professional development on student achievement.
Not all professional development programs improve student achievement all the time. Shymansky, Yore, and Anderson (2004) reported their findings from a study conducted with 238 K-6 teachers. This study was based on a 5-year project called Science, Parents, Activities, and Literature (Science PALs). In addition to teachers, approximately 3,400 parents participated in special training sessions designed to integrate them into the K-6 science program. Across the 5 years of Science PALs, teachers received an average of 110 hours of professional development designed to enhance their science content and pedagogical knowledge. The effectiveness of the program was measured by (a) teacher ratings of the Science PAL program (a Likert-type scale ranging from 1-5); (b) six student assessments prepared with TIMSS 1997 questions, with each assessment consisting of 25 multiple-choice and seven constructed-response relevant to the science topics addressed in the district’s science framework; and (c) students’ attitudes with a Likert-type scale measured by the Student Perception of Classroom Climate, an instrument designed by the investigators. Results indicated that students’ TIMSS scores did not significantly improve either on multiple-choice or constructed response when analyzed by the number of years a student’s teacher was involved in Science PALs program or the rating of the program by the teacher. One of the reasons given for no impact on student achievement is that teacher workshops focused on inquiry models specific to their teaching responsibilities and how to adapt the science kits to their classrooms. Such activities do not fully reflect the complete challenge for teachers while implementing inquiry-based teaching, may not be an effective strategy in professional development, and did not help the teachers to enact the newly developed methods of teaching in their classrooms. Another explanation is that the quasi-experimental approach did not capture the success in some situations. Such studies indicate the importance of doing longitudinal studies in professional development programs.
What Are the Present Problems of Professional Development?

Despite the consensus about the characteristics of professional development and its benefits for mathematics and science teachers, there is a dissonance between the ideal professional development program and the actual professional development programs. Due to the scarcity of longitudinal studies in this area (Huffman & Thomas, 2003; Shymansky et al., 2004), research linking professional development with student achievement is inconclusive. The quality of professional development from the teachers’ perspective about the programs is consistently analyzed through various surveys.

In order to assess the current status of professional development in the United States, results from the federal Schools and Staffing Survey 2003-2004 were presented in National Staff Development Council by Darling-Hammond et al. (2009). The positive findings were evidence of an increase in the number of schools and districts providing high-quality support for teachers. Such well-designed professional development programs are relatively rare, and few teachers have access to such programs (Blank, de Las Alas, & Smith, 2007). Also, the survey results draw attention to specific problems in professional development that explain the disparity between the ideal and actual professional development programs from the teachers’ perspective.

Darling-Hammond (2009) referred to the statistics from the School Staffing Survey in which approximately 53,000 teachers from 10,000 schools in 5,000 districts participated, indicating that a majority of teachers (57%) said that they had received no more than 16 hours of professional development on the subjects they taught. The intensity and duration of professional development offered to U.S. teachers is not at the level recommended in research. Teachers stated that much of the professional development was not useful to them. Their top priorities for further professional development were learning more about the content they teach, classroom
management, teaching students with special needs, and using technology in the classroom. Further available research discussed the problems specifically for mathematics and science teachers.

Loucks-Horsley et al. (2003) claimed that much professional development for mathematics and science teachers (a) lacks opportunities for educator participation; (b) is not aligned to the needs and learning goals emphasized by education reforms; (c) does not provide sufficient support to teachers; (d) focuses more on individual change than on whole-school change; and (e) provides minimal innovative strategies, which, in turn leads to minimal impact in the classroom. The whole-school participation recommended by research appears to be absent in many professional development programs (Anderson, 2002; Hart & Lee, 2003; Johnson, 2006). This may be due to the difficulty of getting all content area teachers to participate, in addition to funding problems. Although many problems exist in narrowing down professional development that assures success to students, efforts are being made to improve the rigor of studies specifically designed to examine this relationship (Wayne, Yoon, Cronen, Garet, & Zhu, 2008).

Ultimately, what teachers know and learn is important. Time teachers spend in professional development can make a difference only when the activities focus on high-quality subject matter. The success of any professional development program depends on how well it is accepted by the participants, because they make the choice to implement what they have learned in the classroom (Gess-Newsome et al., 2003).

In the present education policy environment, a high priority has been placed on improving teacher quality and teaching effectiveness in U.S. schools (Darling-Hammond et al., 2009). Standards-based educational improvement requires teachers to have in-depth knowledge of their subject and the pedagogy that is most effective for teaching the subject. States and school
districts are charged with establishing and leading professional development programs, some with federal funding support that will address major needs for improved preparation of teachers. Addressing teacher quality, including teacher preparation and ongoing professional development, and improving teacher effectiveness in classrooms is at the heart of efforts to improve the quality and performance of U.S. public schools (CCSSO, 2000).

Yoon et al. (2007) stated that professional development affects student achievement in three ways: (a) it enhances teacher knowledge and skills, (b) better knowledge and skills improve classroom teaching, and (c) improved teaching raises student achievement. Few rigorous studies address the effect of professional development on student achievement because adequate student achievement data and sufficient time between the professional development and the measurement of teacher and student outcomes are difficult to attain (Borko, 2004; Kennedy, 1998; Loucks-Horsley & Matsumoto, 1999; Suppovitz & Turner, 2000).

Because good teachers are the foundation of schools, improving teachers’ knowledge is one of the important investments of time and money that local, state, and national leaders should make in education. Acknowledging the importance of useful professional development, various states offer a variety of professional development to teachers. Finally, as public schools are spending approximately $20 billion annually on professional development activities, it is vital to study the impact of professional development in teaching practices and improvements in student learning (NCES, 2007b).

State Initiatives

The Statewide Systemic Initiatives (SSI) program established in 1990 was a major effort by NSF to encourage improvements in science, mathematics, and technology education through
comprehensive systemic changes in the education systems of states. Many educators and scholars believe that meaningful reforms can be achieved through state initiatives that set specific learning goals and standards, stimulate school initiatives, and mobilize resources to support changes. This approach is referred to as systemic reform (Webb, Century, Davilla, Neck, & Osthoff, 2001).

In 1990, NSF instituted a new Directorate for Education to promote and enhance the vitality of mathematics and science in the country (Webb et al., 2001). Because the goal was national impact, they adopted an approach that would address all levels of mathematics and science education instead of concentrating on specific pieces such as curriculum, pedagogy, and professional development (Clune, 1998; Knapp, 1997; Zucker, Shields, Adelman, Corcoran, & Geertz, 1998). These were called the Systemic Statewide Initiatives (SSI). The primary goal of SSI is high quality science, mathematics, and technology education for all students. There also are state funded initiatives with similar goals.

Commencing in 1991, NSF awarded cooperative agreements to states that proposed initiatives geared to achieving the vision of SSI. In 1995, the NSF initiated the local systemic change (LSC) through teacher enhancement. The initiative’s primary goal was to improve instruction in mathematics, science, and technology through professional development for whole school districts. The LSC projects served a variety of districts, schools, and students (Banilower, Boyd, Pasley, & Weiss, 2003).

Based on the commitment to systemic reform, the SSI program funded 25 states initially for 5 years. Horizon research conducted nationwide teacher surveys to evaluate the effectiveness of the professional development programs offered through this funding. Of these states, quantitative and qualitative data were collected from 14 states. The effectiveness of SSI on
student achievement has been measured via student achievement in mathematics and science from the NAEP results, between 1992-2000, and the professional development strategies used to improve student achievement. The results indicate that some states showed no increase in student achievement, some states showed a moderate increase, and some states showed a large increase (Heck, Weiss, Boyd, Howard, & Suppovitz 2003). Participating states, however, used a variety of strategies to improve student achievement, although the common strategy seen among all was professional development.

States such as California, Maine, Missouri, Nebraska, and New Mexico showed no increase in student achievement in mathematics and science between 1992 and 2000 in their NAEP scores. Some of these states had short-term professional development that lasted less than 20 hours, 1-day workshops, and distance learning (Heck et al., 2003). In order to see improvement in student achievement, sustained professional development is necessary (Guskey & Yoon, 2009), and workshops or fragmented professional development conferences do not serve the purpose (Borko, 2004).

States such as Arkansas, Connecticut, Georgia, and South Carolina showed moderate increases in student achievement in NAEP mathematics and science in a span of 8 years. Arkansas instituted professional development planned in collaboration with mathematicians and scientists. Connecticut offered funds to teachers to take classes in content and pedagogy. Georgia offered a variety of services such as educating teachers, fellowships to teachers, and mentoring for teachers. South Carolina provided measures to scale up that addressed all schools in the state by providing equitable access to exemplary curricula, instructional materials, professional development, and other support for reform. Professional development contributed to the success of these initiatives (Crawford & Banilower, 2004; Garet et al., 2001; Heck et al., 2003).
States such as Kentucky, Massachusetts, Michigan, New York, and Louisiana showed steady and large increases in students’ academic achievement from 1992 to 2000 in NAEP scores. In Kentucky, professional development was emphasized by enlisting mathematics specialists from universities to develop materials for professional development programs, field testing the developed materials, and establishing model sites to implement curricula and pedagogy. Onsite consulting and support were provided to teachers. All these measures collectively contributed to the success of the professional development program in Kentucky (Heck et al., 2003; Pasley, 2002).

Massachusetts is another state that showed a large increase in student achievement through state initiatives. Its main activity was professional development for K-12 teachers and education for mathematics and science teachers. Thirteen demonstration sites were selected, and specialists received intensive training for 1 year in mathematics and science content; later the specialists returned to their sites as trainers. Regional summer institutes were organized to train more people. These trainers led activities in subsequent summer institutes organized by specialists. Further support was given in implementation of a standards-based curriculum, materials management, and use of technology. Standards were upgraded for credentialing teachers of mathematics and science. Success was attributed to sustained professional development in summer institutes, continued support through mathematics and science specialists, and adequate materials for implementation (Garet et al., 2001, Heck et al., 2003; Pasley, 2002).

Michigan also showed a steady and high increase in student achievement. This state reviewed state policies and federal programs in nine school districts and examined how state and local policies interact to influence mathematics and science instruction. Teacher Education
Redesign was formed to help Michigan colleges and universities improve their preservice programs. The professional development component focused on enhancing the statewide infrastructure for professional development, used a special issue of the initiative’s newsletter to communicate a new paradigm of professional development, worked with professional development providers to upgrade services with a vision of high quality mathematics and science education, and worked with policymakers to incorporate new principles for high quality mathematics and science education into state policy. Michigan’s professional development program, in collaboration with the university, is considered to be the main reason for its success (Heck et al., 2003; Pasley 2002).

Another state that showed a significant increase in student achievement is New York. The New York Statewide Systemic Initiative consisted of state-level activities to influence policy alignment and the Urban Network project to carry out local-level reform in New York’s six largest underscoring districts. The plan of the initiative was to take the message of higher standards in mathematics, science, and technology to all schools in the state. This was achieved by developing curriculum guidelines, administering statewide needs assessment to teachers, and providing professional development based on the response to those needs, identifying 300 schools to train as demonstration schools, and focusing on teacher education through sustained professional programs. The success of this program has been attributed to sustained professional development based on the needs of the teachers (Heck et al., 2003).

Another statewide initiative showing higher student achievement is the Louisiana State Initiative. The Louisiana Board of Regents for Higher Education is the lead institution for the initiative. The initiative had professional development as the major focus. This professional development model is based on (a) specifically designed course content with concentration on
reasoning, investigating, and practical understanding of concepts; (b) recruitment of mathematics and science teachers in pairs for each institute; (c) summer institutes providing 120-180 hours of concentrated, integrated exposure to grade-level relevant content and methods of teaching; (d) academic follow-up activities including class-room visits and on-site support for teachers; (e) materials and resources for participants who completed summer institutes; (f) graduate credit for successful participation in the project; and (g) stipends per day for program participants. The Louisiana SSI, planned and implemented by mathematicians, scientists, mathematics and science educators, and teacher leaders, is considered to be one of the best SSIs, and has been considered a model program for other states that wanted to start an SSI (Heck et al., 2003; Pasley, 2002).

All the states that have shown large increases in student achievement have focused on collaborative, sustained, content focused professional development designed by mathematicians, scientists, and university faculty based on the needs of the teachers. Such programs offer continued support through onsite training and providing materials for teachers. All of these are considered as essential characteristics of effective professional development programs (Banilower, 2000; Bowes & Banilower, 2004; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Loucks-Horsley et al., 1998).

Alabama Math, Science, and Technology Initiative

Most students in Alabama were performing at the minimal basic level in mathematics and science when compared nationwide. Thus the academic success of Alabama’s students was a major concern to the State Superintendent of Education, Dr. Ed Richardson, and Deputy State Superintendent of Education Dr. Joseph Morton. They decided, in 1999, that there was a serious need to improve mathematics and science instruction in Alabama. As a result, the Alabama,
Math, Science, and Technology Education Committee (AMSTEC) was formed as an effort to help improve mathematics and science teaching statewide. The purpose of this committee was to provide all students in Grades K-12 with the knowledge and skills necessary for success in the workforce (AMSTI, 2009a).

History of AMSTI

This blue ribbon committee appointed by the Alabama State Department of Education (ASDE) was comprised of classroom teachers and administrators, university faculty, and leaders from business and industry. They began the process of creating a statewide program aimed at improving mathematics and science education. The blue ribbon committee wanted to come up with the most effective statewide initiative for improving mathematics and science teaching. Therefore they were strategic and followed a series of steps (AMSTI, 2009a).

The steps included (a) examining international, national, and state assessment data; (b) reviewing programs already in Alabama; (c) addressing the needs of business and industry; (d) investigating the needs of teachers through a national survey; (e) understanding the national standards and its implications; (f) reviewing initiatives in other states such as Minnesota, South Carolina, and Louisiana; and (g) reviewing the existing literature on SSI. Every effort was made to ensure that the initiative was research based and used best teaching practices (AMSTI, 2009a).

This committee worked for a year creating recommendations for the initiative. By the end of 2000, the State Board of Education accepted the recommendations, and the Alabama Math, Science, and Technology Initiative (AMSTI) became the official name for the initiative. Following this, a plan for implementing AMSTI was established. This called for establishing initiative support sites across the state, referred to as AMSTI sites, to implement the state’s
initiative within the state’s 11 geographical Regional Inservice center areas. Each of the AMSTI sites would work under the direction of the State Department of Education (AMSTI, 2009a).

Once the recommendations were adopted, the State Department of Education (SDE) appointed committees to the initiative. One committee was responsible for selecting the science curricula for specific grades and materials (modules) that would be given to teachers during the first year of training. The science modules were selected from kits already done. They were Full Options Science System (FOSS) kits and the Science and Technology Concepts Program (STC). All of the science modules had a research base and were developed with the support of NSF (AMSTI, 2009a).

Another committee selected the math curricula and materials for specific grades. The mathematics modules were selected from *Investigations in Number, Data, and Space (Investigations)*, which incorporated exemplary curricula from a U.S. Department Education’s panel. *Investigations* are a complete K-5 curriculum, developed at TERC in Cambridge. It is designed to help all children understand fundamental ideas of numbers and operations, geometry, data, measurement, and early algebra.

Once the science and mathematics curricula were decided on for specific grades, trainers were hired. Upon completing the training, the trainers tested the materials in their classrooms. The same process was repeated during the following year. Thus, this process occurred from 2001-2003 (AMSTI, 2009a).

Funding was a problem, so connections were established with institutions of higher education, business, and industry. In spring 2002, with the help of Congressman Bud Cramer, AMSTI received a $3 million grant from the National Aeronautics and Space Administration to fund the first AMSTI site. The University of Alabama at Huntsville (UAH) was chosen to pilot
the first AMSTI site. In addition to this site, a small grant was awarded to the University of North Alabama (UNA) to begin setting up a materials center and training teachers (AMSTI, 2009a).

Approximately 250 teachers from 20 schools attended the first summer institute at UAH campus during summer 2002, and these schools were referred to as the first official AMSTI schools. During summer 2003, AMSTI teachers returned to UAH for their second year of training. At the same time a new group of teachers started their first year of training at UAH. Because training first- and second-year participants proved successful at UAH, this model was adopted for future training (AMSTI, 2009a).

During the winter of 2003-2004, the University of South Alabama (USA) was awarded an AMSTI site and it became the second site. Funding was provided by the U.S Department of Education’s Math, Science Partnership grants that come to the Alabama State Department of Education. USA conducted its first Summer Institute with approximately 350 teachers and administrators during summer 2004 (AMSTI, 2009a).

During the spring of 2004, the first evaluations of student achievement as measured by standardized tests were released. The impact of AMSTI on student performance on standardized tests report was developed by the Institute for Communication and Information Research at The University of Alabama. The external evaluator examined the performance of AMSTI schools and non-AMSTI schools. The study compared 75 AMSTI schools to a comparable group of 265 non-AMSTI schools. Data from the Stanford Achievement Test (10th edition), Alabama Reading and Math Test, Alabama Direct Assessment of Writing, and Alabama High School Graduation exam were used to do the comparison (AMSTI, 2009c).
According to this report, AMSTI schools scored higher than non-AMSTI schools in mathematics and science after 1 year of implementation. Scores in the third year showed statistically significant gains. It was noticed that AMSTI appeared to help increase the scores for reading and writing. One of the reasons cited for this gain was that AMSTI had incorporated reading and writing in the modules. During summer 2005, Governor Riley adopted AMSTI as one of his major goals for funding. The state legislative budget passed during spring 2005 and contained $15 million dollars to continue and expand for the Fiscal Year 2006 budget (AMSTI, 2009a).

In the spring of 2005, requests for proposals of new sites were distributed. By September, new sites were announced at the University of Montevallo (UM), Troy University (Troy U), The University of Alabama (UA), Wallace Community College-Selma (WCCS), partnering with Alabama State University (ASU), and Jacksonville State University (JSU). Of these three sites UM, UA, and Troy University were funded at all levels, which allowed them to be fully operational; hence, they conducted Summer Institutes for their in-service regions in the summer of 2006 (AMSTI, 2009a).

The 2007 funding of $22 million by the Alabama legislature allowed the eight AMSTI sites to continue to support previously trained schools in addition to adding two new sites at Auburn University (AU) and University of Alabama at Birmingham (UAB). During the summer of 2007, over 5,000 teachers attended the Summer Institute. One hundred sixty-eight new AMSTI schools were added, bringing the total number of schools served to 364 which is one-fourth of all public schools in Alabama. (AMSTI, 2009a).
Schools’ Participation in AMSTI and Professional Development for Teachers

The initiative serves math and science teachers in Grades K-12. In addition, all school administrators and special education teachers that teach are involved in supporting math and science instruction. The goal of AMSTI is to provide three basic services: professional development, equipment and materials, and on-site support to participating teachers.

Schools become official AMSTI schools by sending 80% of their math and science teachers, and their administrators to a 2-week summer institute for two consecutive summers. At the summer institute, teachers are grouped by grade level (K-12) and subject. In these groups, teachers receive instruction that is specific to their own classrooms. The instruction is given by “master” teachers who have been certified as trainers. Instruction focuses on inquiry-based, hands-on teaching utilizing research-based curricula developed with the support of NSF. The curricula are aligned with national and state standards (AMSTI, 2009a).

The main concerns of professional development programs are strengthening teachers’ content knowledge and providing sustained professional development, access to equipment, collaborative learning, and on-site support for teachers (Darling-Hammond, 2009). Specifically, the 2-week summer institute instruction addresses depth of content, instructional methods and techniques, alternative assessments, journal writing, inquiry implementation, and classroom management. Teachers participate in the activities that they will use with their students (AMSTI, 2009b).

After completing the 2-week training, participants are provided with all the equipment, resources, and supplies needed to implement the training in their classrooms. In addition, on-site support and mentoring is provided to the participants. Once teachers complete the summer institute, math and science specialists from the site regularly visit the schools where they serve as
mentors, helping teachers implement what was learned. Such support is vital for teachers to become comfortable and skilled at inquiry-based, hands-on learning (AMSTI, 2009b). This support can be provided through ongoing professional development programs.

Sustained professional development programs for teachers can significantly improve student achievement in mathematics and science (Darling-Hammond, 2009). Steve Ricks, AMSTI director, said on every standardized test given by the State Department of Education, AMSTI schools outperformed non-AMSTI schools. Thus, Ricks said, with adequate funding, AMSTI could expand services in all 11 regional sites and raise the number of participating schools from 600 to 900 (AMSTI, 2009b).

Studies on AMSTI

In addition to the reports published by AMSTI, other studies on AMSTI have also been conducted. So far at least four studies on teachers’ perceptions of AMSTI have been conducted by Stewart (2008); Kelley (2007); Pistorius (2006); and Penuel, Fishman, Gallagher, Korbak, and Lopez-Prado (2008). A mixed-methods dissertation by Stewart (2008) at Alabama State University was conducted to find out teachers’ and administrators’ perceptions of the effects of participation in AMSTI in K-5 schools. Furthermore, this study examined the achievement of students in 16 AMSTI and non-AMSTI schools. The results of the study showed that student achievement in AMSTI schools was better compared to non-AMSTI schools.

However, according to Stewart (2008), there was no statistically significant increase in the scores between AMSTI and non-AMSTI schools. Overall responses from teachers and administrators agreed that teachers benefited from the professional development activities provided by AMSTI, materials and supplies were an important part of the Initiative, student
achievement had increased, and there was improvement in student attitudes, especially toward learning math and science.

Another dissertation on elementary teachers’ perceptions of AMSTI mathematics and its impact on teachers’ instructional practices was conducted by Kelley (2007) at The University of Alabama. This mixed-methods study investigated 43 K-5 elementary teachers’ perceptions of AMSTI and classroom instructional practices that resulted from participation in the AMSTI training. Results indicated grade level significantly affected the perceptions of training, implementing, and practices. Teachers in all grade levels reported that they used more hands-on learning, problem solving, and cooperative learning, and had better utilized questioning and discussions with students; however, K-1 teachers had more favorable perceptions than any other grade level teachers. According to Kelley (2007), due to AMSTI training, the instructional practice of teachers showed more constructive practice as advocated by NCTM.

Pistorius (2006) conducted a dissertation on teachers’ perceptions and use of AMSTI for middle school science. She investigated 85 middle school teachers using an AMSTI science survey and interviewed 14 of these teachers in Grades 6-8 who had completed their year one AMSTI science training in 3 regions. Results of this mixed-methods study indicated that the more professional development experienced by teachers was related to the number of lessons the teacher used from AMSTI modules. According to Pistorius, the more professional development the teachers received the higher they self-supported their level of expertise in teaching the AMSTI science modules. According to Pistorius, some of the strengths of AMSTI are FOSS kits, easy access to all materials needed for inquiry-based learning, teachers’ manuals, and the training required to use the materials effectively. Some of the weaknesses of AMSTI as reported
in this study include lack of communication between teachers and those involved with materials management.

Another quantitative study on AMSTI science training was conducted by Penuel et al., (2008). The participants were 225 teachers from 51 different schools from three regional institutes who attended the AMSTI professional development institute during summer 2006 as their second year of training. In AMSTI science training, one of the sessions offered in science is Global Learning and Observation for the Benefit of Environment (GLOBE). GLOBE is a science project where students gather data concerning air temperature, soil temperature, amount of rainfall, and wind conditions. Collected data is then recorded on a website where students can compare data sources from around the world. In the summer training, participants were taught how to use this program 2 out of 5 days (40%) of science training. Elementary teachers’ perceptions of GLOBE were collected through surveys. The data collected in this study showed that a majority of the teachers who took part in the initiative did not implement GLOBE protocols with students in their classrooms. Furthermore, although most teachers perceived the program as consistent with their own goals of professional development, nearly one-fifth of the teachers responded that GLOBE materials are not “sufficiently consistent” with these goals.

However, the success of any professional development program depends on how it appeals to the teachers because they take the training to the classrooms. AMSTI offers mathematics and science training for 2 weeks during two consecutive summers. Thus, it is vital to study the impact of the training in teachers’ instructional strategies.
Summary

In the past 5 decades since the Russian’s launch of Sputnik, efforts have been made to improve the mathematics and science education in the U.S. Despite the efforts, the improvement in mathematics and science education is relatively low as reflected in national and international reports of student achievement. However, future jobs require proficiency in mathematics and science to compete globally. Ways to improve student achievement could be achieved by increasing content and pedagogical knowledge for teachers through effective professional development and devoting more time to teaching subjects such as science.

Efforts to reform mathematics and science education have been ongoing since the early 1960s. Research indicates that teachers need to have more content knowledge and pedagogical expertise in order to successfully implement the major reform ideas in mathematics and science. One of the ways teachers can gain this expertise is through professional development programs. The National Science Foundation has supported many programs for teachers in mathematics and science. Some of these have become state initiatives.

Some of the statewide programs have been successful and others have not been successful. The main reasons for the success of professional development programs are extended time, emphasis on content and pedagogy, classroom application, and acceptance by the participants. The state initiative in Alabama for improving mathematics and science education is the Alabama Mathematics, Science, and Technology Initiative (AMSTI). AMSTI provides three basic services: professional development, equipment and materials, and on-site support. The AMSTI website states that student achievement in mathematics and science is greater in AMSTI schools than non-AMSTI schools. However, there is no published research concerning student achievement.
achievement and AMSTI. Also, there is lack of information about the AMSTI teachers and their perceptions of the AMSTI training and implementation.
CHAPTER III

METHODOLOGY

The purpose of this study was to investigate elementary teachers’ perceptions of the Alabama Math, Science, and Technology Initiative’s (AMSTI) professional development training and implementation in mathematics and science at the elementary level. Furthermore, this study examine whether teachers perceived that changes in their instructional strategies occurred in mathematics and science as a result of the AMSTI training. This chapter focuses on methods of investigation and includes (a) research questions, (b) permission for the study, (b) researcher’s positionality, (c) pilot study, (e), setting and participants, (f) instrumentation, (g) design of the study, (h) member checking, and (i) data analysis.

Research Questions

1. Is there a difference in second year K-5 teachers’ perceptions of AMSTI training, implementation, and practices in mathematics and science across grade levels?

2. What are the second year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in mathematics?

3. What are second year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in science?

4. What are second year AMSTI trained K-5 teachers’ perceptions of AMSTI mathematics?

5. What are second year AMSTI trained K-5 teachers’ perceptions of AMSTI science?
Permission for the Study

Permission for the study was obtained from the Institutional Review Board (IRB) for the protection of human subjects (see Appendix A). Before data collection, participants were given consent forms, which explained the study in detail. The consent form also explained that participation was voluntary and raw data would be destroyed upon completing the study (see Appendix B). Permission was obtained from the superintendents of the schools district where the study was conducted.

Researcher’s Positionality

I was born and brought up in Madurai, South India, also known as the temple city, which is famous for classical literature, South Indian music (Karnatic), and South Indian dance (Bharatanatyam). I had my education from preschool to my Master’s degree in the temple city. I earned my B.A (Social Sciences) in 1986 and M.A (Literature) in 1988. In the summer of 1988, I earned a diploma in Montessori education for primary grades. Following this diploma I worked as a kindergarten teacher. In 1990 December I emigrated to the U.S. During the years 1992-2001, I spent time raising my children in this new country. Once the last child was enrolled in school full time, I started working again as a preschool teacher in a private school at Tuscaloosa (2001-2003). The preschool system in this school has Montessori elements combined with Multiple Intelligence Strategies.

After working 2 years at this school, I took a few classes at The University of Alabama (UA) to see if I could come back to school since there was a long gap after my education in India. Soon I realized I could comfortably manage a small load of course work with a family and work. Later I increased the course work and quit working (2003). Then I joined the alternate
certification program at UA (2003) and pursued a Master’s degree in elementary education, which I earned in 2005.

Upon completing the M.A degree at UA, I taught mathematics for fifth-grade students and science for fifth- and sixth-grade students in a private school (2005-2007). I started my Ed.S in 2005 in Elementary Education at UA. I was interested in knowing the attitudes of students about word problems. I selected the text *Investigations* (Kliman, Tierney, Murray, & Akers, 1995), which has many word problems for inquiry-based learning while understanding mathematics. I conducted an experimental study for 4 weeks in my fifth-grade mathematics classroom using “*Investigations*.” Students had to solve word problems and explain how they solved them.

The topic of the Ed.S. research study was “The impact of *Investigations* on students’ attitudes and abilities in solving word problems.” One of the findings of this study indicated that introducing a curriculum such as *Investigations* created a positive impact on the attitudes and abilities of students in solving math word problems. *Investigations* is a standards-based method of teaching mathematics. It recommends inquiry-based activities and incorporates writing to explain students’ conceptual understanding. I earned an Ed.S in 2007.

After this experience, I moved and worked in a public school in South Alabama and taught mathematics in fifth and sixth grades (2007-2008) for 1 year while pursuing my doctoral degree. The school where I worked was an AMSTI school and all the teachers had received mathematics materials and science kits after their training; however, there were teachers who implemented the AMSTI in their classrooms and there were teachers who did not.

The varied experiences I had in private and public schools aroused my curiosity in elementary mathematics and science. Also, I have had an admiration for mathematics since
childhood. During the summer 2009 I attended (as an observer) the AMSTI Summer Institute professional development offered in Tuscaloosa. At the Summer Institute, K-5 teachers were trained for 2 weeks, 1 week in teaching mathematics and the other in teaching science. Each teacher was trained for the grade level of responsibility.

Pilot Study

In order to determine the validity and reliability of the instruments used in this study, a pilot study was conducted with 100 K-5 elementary teachers served by the University of South Alabama In-service region. These teachers were purposefully selected for the pilot study. They all had participated in the 2009 Summer Institute in Baldwin County as second-year AMSTI participants.

The content validity was established by a panel of six experts, the mathematics questionnaire by mathematics educators, and the science questionnaire by science educators. All the panel members were familiar with the AMSTI professional development program. Each panel member read the questionnaire and made continuous suggestions until all agreed that the questions were acceptable and would cover the intent of the study.

The survey responses from the pilot study were analyzed for construct validity with principal components analysis with a varimax, orthogonal rotation. Principal component analysis provided one of the tools required to define the underlying dimensions of variables in construct validity. Of the 22 items in the AMSTI mathematics questionnaire, the most interpretable solution was three components with an eigenvalue of 1.00 or greater.

Principal component analysis of the AMSTI mathematics questionnaire with varimax rotation was computed. The underlying dimension identified by each component is as follows:
(a) training, (b) implementation, and (c) practice. Principal component analysis for mathematics is presented in Table 1.
Table 1

Principal Component Analysis of the AMSTI Mathematics Questionnaire with Varimax Rotation

<table>
<thead>
<tr>
<th>Item</th>
<th>Component I: Training</th>
<th>Component II: Implementation</th>
<th>Component III: Practice</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 Hands-on activities</td>
<td>.832</td>
<td>.197</td>
<td>.006</td>
<td>.731</td>
</tr>
<tr>
<td>16 Encourage discussion</td>
<td>.801</td>
<td>.335</td>
<td>.054</td>
<td>.756</td>
</tr>
<tr>
<td>15 Multiple forms of assessments</td>
<td>.788</td>
<td>.271</td>
<td>.131</td>
<td>.712</td>
</tr>
<tr>
<td>6 Conceptual understanding</td>
<td>.729</td>
<td>.188</td>
<td>.250</td>
<td>.629</td>
</tr>
<tr>
<td>12 More problem-solving</td>
<td>.712</td>
<td>.279</td>
<td>.139</td>
<td>.604</td>
</tr>
<tr>
<td>4 Cooperative learning</td>
<td>.601</td>
<td>.261</td>
<td>.355</td>
<td>.556</td>
</tr>
<tr>
<td>14 Training in content and pedagogy</td>
<td>.587</td>
<td>.185</td>
<td>.383</td>
<td>.525</td>
</tr>
<tr>
<td>13 Less emphasis on computation skills</td>
<td>.586</td>
<td>.065</td>
<td>.394</td>
<td>.502</td>
</tr>
<tr>
<td>21 Increased motivation in students</td>
<td>.236</td>
<td>.809</td>
<td>.096</td>
<td>.719</td>
</tr>
<tr>
<td>19 Materials improve comprehension</td>
<td>.343</td>
<td>.773</td>
<td>.187</td>
<td>.751</td>
</tr>
<tr>
<td>22 Effective way to teach mathematics</td>
<td>.355</td>
<td>.753</td>
<td>.150</td>
<td>.715</td>
</tr>
<tr>
<td>20 Effective mathematics teacher</td>
<td>.474</td>
<td>.696</td>
<td>.084</td>
<td>.715</td>
</tr>
<tr>
<td>18 Effective questioning</td>
<td>.577</td>
<td>.598</td>
<td>-0.10</td>
<td>.690</td>
</tr>
<tr>
<td>9 Meets needs of diverse students</td>
<td>.394</td>
<td>.555</td>
<td>.307</td>
<td>.558</td>
</tr>
<tr>
<td>7 Adequate manipulatives provided</td>
<td>.105</td>
<td>.552</td>
<td>.530</td>
<td>.597</td>
</tr>
<tr>
<td>11 Support from administration</td>
<td>-0.10</td>
<td>.459</td>
<td>.372</td>
<td>.350</td>
</tr>
<tr>
<td>10 Implement AMSTI fully</td>
<td>.127</td>
<td>-0.10</td>
<td>.794</td>
<td>.647</td>
</tr>
<tr>
<td>5 Comfortable with math specialist</td>
<td>.072</td>
<td>.000</td>
<td>.654</td>
<td>.433</td>
</tr>
<tr>
<td>3 Confident using manipulatives</td>
<td>.109</td>
<td>.245</td>
<td>.586</td>
<td>.416</td>
</tr>
<tr>
<td>1 2008 summer training was useful</td>
<td>.380</td>
<td>.341</td>
<td>.567</td>
<td>.582</td>
</tr>
<tr>
<td>2 2008 summer training was necessary</td>
<td>.232</td>
<td>.433</td>
<td>.546</td>
<td>.539</td>
</tr>
<tr>
<td>8 Collective participation provides support</td>
<td>.326</td>
<td>.229</td>
<td>.420</td>
<td>.335</td>
</tr>
</tbody>
</table>

Sum of the squares of component loadings 6.403 4.343 3.316 14.062
Variability 24.561 19.742 15.071 59.374

Note. Extraction method: Principal Components, N=100.
The components were (a) training, (b) implementation, and (c) practice. In mathematics, the first component accounted for 24.561% of the variance, the second component accounted for 19.742% of the variance, and the third component accounted for 15.071% of the variance.

Reliability coefficients for the three components were (a) training, .762; (b) implementation, .900; and (c) practice, .897. Correlation coefficients for the components are presented in Table 2.

Table 2

*Reliability Coefficients for the Three Components in Mathematics*

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale mean if item deleted</th>
<th>Scale variance if item deleted</th>
<th>Correlated item-total correlation</th>
<th>Squared multiple correlation</th>
<th>Cronbach’s Alpha if item deleted</th>
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</thead>
<tbody>
<tr>
<td>Item-total statistics for Training--Correlation Coefficients</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>14.95</td>
<td>5.421</td>
<td>.648</td>
<td>.462</td>
<td>.692</td>
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<tr>
<td>2</td>
<td>14.85</td>
<td>5.412</td>
<td>.615</td>
<td>.438</td>
<td>.699</td>
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<tr>
<td>3</td>
<td>14.84</td>
<td>5.941</td>
<td>.432</td>
<td>.251</td>
<td>.745</td>
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<tr>
<td>5</td>
<td>15.10</td>
<td>5.654</td>
<td>.461</td>
<td>.257</td>
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<tr>
<td>8</td>
<td>14.92</td>
<td>5.983</td>
<td>.352</td>
<td>.205</td>
<td>.767</td>
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<tr>
<td>10</td>
<td>15.40</td>
<td>5.133</td>
<td>.549</td>
<td>.320</td>
<td>.715</td>
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<tr>
<td>Item-total statistics for Implementation--Correlation Coefficients</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>22.34</td>
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<td>.620</td>
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<tr>
<td>9</td>
<td>22.41</td>
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</tbody>
</table>
After examining the principal components of the 22 items in science, a two-component solution was retained, which provided the best simple structure. Item 1 did not load on any component with the .40 criterion. The underlying dimensions identified by each component are as follows: (a) training/implementation and (b) practice. Principal component analysis for science is presented in Table 3.
Table 3

**Principal Component Analysis of the AMSTI Science Questionnaire with Varimax Rotation**

<table>
<thead>
<tr>
<th>Item</th>
<th>Component I: Practice/Implementation</th>
<th>Component II: Training</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 Materials help in understanding science</td>
<td>.855</td>
<td>.279</td>
<td>.808</td>
</tr>
<tr>
<td>18 Effective questioning due to training</td>
<td>.819</td>
<td>.239</td>
<td>.727</td>
</tr>
<tr>
<td>20 Effective science teacher due to training</td>
<td>.813</td>
<td>.285</td>
<td>.743</td>
</tr>
<tr>
<td>16 Encourage discussion</td>
<td>.802</td>
<td>.278</td>
<td>.720</td>
</tr>
<tr>
<td>17 Hands-on- activities</td>
<td>.800</td>
<td>.162</td>
<td>.667</td>
</tr>
<tr>
<td>22 AMSTI promotes effective science teaching</td>
<td>.781</td>
<td>.306</td>
<td>.703</td>
</tr>
<tr>
<td>15 Multiple forms of assessment</td>
<td>.772</td>
<td>.221</td>
<td>.645</td>
</tr>
<tr>
<td>12 Inquiry learning (problem-solving)</td>
<td>.758</td>
<td>.272</td>
<td>.648</td>
</tr>
<tr>
<td>9 Meeting the needs of diverse students</td>
<td>.683</td>
<td>.409</td>
<td>.633</td>
</tr>
<tr>
<td>21 Increase in motivation to learn science</td>
<td>.674</td>
<td>.347</td>
<td>.575</td>
</tr>
<tr>
<td>4 Cooperative learning</td>
<td>.660</td>
<td>.456</td>
<td>.643</td>
</tr>
<tr>
<td>6 Time spent on student’s conceptual knowledge</td>
<td>.626</td>
<td>.481</td>
<td>.623</td>
</tr>
<tr>
<td>14 Training in content and pedagogy</td>
<td>.591</td>
<td>.225</td>
<td>.400</td>
</tr>
<tr>
<td>7 Adequate materials provided</td>
<td>.568</td>
<td>.288</td>
<td>.406</td>
</tr>
<tr>
<td>10 Implement AMSTI fully</td>
<td>.182</td>
<td>.793</td>
<td>.661</td>
</tr>
<tr>
<td>5 Comfortable with science specialist</td>
<td>.011</td>
<td>.778</td>
<td>.606</td>
</tr>
<tr>
<td>2 2008 summer training was necessary</td>
<td>.439</td>
<td>.641</td>
<td>.604</td>
</tr>
<tr>
<td>3 Confident in managing materials</td>
<td>.315</td>
<td>.562</td>
<td>.415</td>
</tr>
<tr>
<td>13 Less time spent on memorization</td>
<td>.464</td>
<td>.555</td>
<td>.524</td>
</tr>
<tr>
<td>8 Collective participation provides support</td>
<td>.260</td>
<td>.509</td>
<td>.327</td>
</tr>
<tr>
<td>11 Support from administration</td>
<td>.204</td>
<td>.436</td>
<td>.232</td>
</tr>
<tr>
<td>1 2008 Summer training was useful</td>
<td>.162</td>
<td>.243</td>
<td>.086</td>
</tr>
<tr>
<td>Sum of the squares of component loadings</td>
<td>8.220</td>
<td>4.176</td>
<td>12.396</td>
</tr>
<tr>
<td>Variability</td>
<td>37.365</td>
<td>18.892</td>
<td>56.257</td>
</tr>
</tbody>
</table>

*Note.* Extraction method: Principal Components, $N=100.$
Of the 22 items in science, two components were derived. They are practices/implementation and training. The first component accounted for 37.365% of the variance and the second component accounted for 18.982% of the variance. Table 4 shows reliability coefficients for the two components in science.

Table 4

Reliability Coefficients for the Two Components in Science

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale mean if item deleted</th>
<th>Scale variance if item deleted</th>
<th>Correlated item-total correlation</th>
<th>Squared multiple correlation</th>
<th>Cronbach’s Alpha if item deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item-total statistics for Practices/Implementation--Correlation Coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>42.61</td>
<td>41.274</td>
<td>.760</td>
<td>.707</td>
<td>.949</td>
</tr>
<tr>
<td>6</td>
<td>42.73</td>
<td>42.068</td>
<td>.751</td>
<td>.713</td>
<td>.949</td>
</tr>
<tr>
<td>7</td>
<td>42.44</td>
<td>43.861</td>
<td>.583</td>
<td>.423</td>
<td>.953</td>
</tr>
<tr>
<td>9</td>
<td>42.51</td>
<td>43.220</td>
<td>.734</td>
<td>.571</td>
<td>.950</td>
</tr>
<tr>
<td>12</td>
<td>42.63</td>
<td>41.139</td>
<td>.769</td>
<td>.649</td>
<td>.949</td>
</tr>
<tr>
<td>14</td>
<td>42.63</td>
<td>42.946</td>
<td>.587</td>
<td>.497</td>
<td>.953</td>
</tr>
<tr>
<td>15</td>
<td>42.65</td>
<td>41.263</td>
<td>.767</td>
<td>.675</td>
<td>.949</td>
</tr>
<tr>
<td>16</td>
<td>42.52</td>
<td>41.779</td>
<td>.805</td>
<td>.754</td>
<td>.948</td>
</tr>
<tr>
<td>17</td>
<td>42.51</td>
<td>41.371</td>
<td>.763</td>
<td>.635</td>
<td>.949</td>
</tr>
<tr>
<td>18</td>
<td>42.61</td>
<td>41.037</td>
<td>.809</td>
<td>.732</td>
<td>.948</td>
</tr>
<tr>
<td>19</td>
<td>42.40</td>
<td>42.265</td>
<td>.864</td>
<td>.877</td>
<td>.947</td>
</tr>
<tr>
<td>20</td>
<td>42.60</td>
<td>40.437</td>
<td>.836</td>
<td>.789</td>
<td>.947</td>
</tr>
<tr>
<td>21</td>
<td>42.32</td>
<td>43.123</td>
<td>.721</td>
<td>.697</td>
<td>.950</td>
</tr>
<tr>
<td>22</td>
<td>42.36</td>
<td>42.599</td>
<td>.803</td>
<td>.867</td>
<td>.948</td>
</tr>
<tr>
<td>Item-total statistics for training--Correlation Coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>19.16</td>
<td>7.369</td>
<td>.642</td>
<td>.445</td>
<td>.746</td>
</tr>
<tr>
<td>3</td>
<td>19.11</td>
<td>8.142</td>
<td>.501</td>
<td>.265</td>
<td>.774</td>
</tr>
<tr>
<td>5</td>
<td>19.25</td>
<td>7.662</td>
<td>.540</td>
<td>.327</td>
<td>.766</td>
</tr>
<tr>
<td>8</td>
<td>19.16</td>
<td>8.248</td>
<td>.432</td>
<td>.251</td>
<td>.785</td>
</tr>
<tr>
<td>10</td>
<td>19.51</td>
<td>6.472</td>
<td>.687</td>
<td>.514</td>
<td>.734</td>
</tr>
<tr>
<td>11</td>
<td>18.83</td>
<td>8.980</td>
<td>.344</td>
<td>.206</td>
<td>.797</td>
</tr>
<tr>
<td>13</td>
<td>19.46</td>
<td>7.613</td>
<td>.526</td>
<td>.368</td>
<td>.769</td>
</tr>
</tbody>
</table>

Note. Cronbach’s alpha for practices/implementation = .953; Cronbach’s alpha for training = .795.
Setting and Participants

The study took place in a school district in South Alabama, different from the pilot study. The school system for this study is divided into city and county schools. The prospective participants included 110 teachers from six elementary schools served by the University of South Alabama In-service Center. These teachers participated in the 2009 Summer Institute year 2 training and were implementing their training at the time of this study (2009-2010).

The first elementary school, Abraham Elementary (pseudonym), is a rural K-5 school. The school had an enrollment of 277 students during 2009-2010 school year. The faculty was comprised of 17 teachers: 3 kindergarten, two first grade, two second grade, three third grade, two fourth grade, two fifth grade, and two special education teachers. All students were African Americans and 93% of the students qualified for free lunch.

The second school, Benjamin Elementary (pseudonym), is a rural K-5 school with a population of 815 students enrolled during the school year 2009-2010. The faculty of 43 teachers includes six kindergarten, seven first grade, seven second grade, seven third grade, six fourth grade, seven fifth grade, and three special education teachers. The ethnic composition was 93% African American, 5% Caucasian, and 2% Asian and Hispanic. Ninety-two percent of the students qualified for free lunch.

The third school, Calvin Elementary (pseudonym), is a school with a population of 446 students during the school year 2009-2010. The ethnic composition was 99.77% African American and 0.22% Caucasian. Ninety-five percent of the students qualified for free lunch. The school had 31 teachers: four teachers in kindergarten, four in first grade, four in second grade, four in third grade, four in fourth grade, four in fifth grade, and three special education teachers.
The fourth school, Dwight Elementary (pseudonym), had a population of 537 students during the school year 2009-2010. Approximately 93% of students were Caucasian, 3% African American, and 4% Asian and Hispanic. Of these students, 46% qualified for free lunch and 11% qualified for reduced lunch. The school faculty included 31 teachers: four kindergarten, five first grade, five second grade, five third grade, five fourth grade, four fifth grade, and three special education teachers.

The fifth school, Franklin Elementary (pseudonym), had a population of 471 students during the school year 2009-2010. Of these students, approximately 74% were African American, 11% were Caucasian, 8% were Hispanic, and 7% were Asian. Of these students, 85% qualified for free lunch. The school faculty included 25 teachers: four kindergarten, four first grade, four second grade, four third grade, four fourth grade, three fifth grade, one Pre-K, and one speech teacher.

The last school, Harry Elementary (pseudonym), is a school with a population of 317 students. All students were African American and 95% of them qualified for free lunch. The school faculty included 17 teachers: two in kindergarten, three in first grade, two in second grade, three in third grade, three in fourth grade, two in second grade, and two special education teachers. Of the total population, 110 participants were second-year AMSTI trained in the year 2009. Demographics and number of K-5 second-year AMSTI trained teachers in each school are listed in Table 5.
Table 5

Demographics of Participating Schools

<table>
<thead>
<tr>
<th>Elementary School</th>
<th>Number of Students</th>
<th>% Caucasian</th>
<th>% African American</th>
<th>% Other</th>
<th>Number of K-5 AMSTI trained teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abraham</td>
<td>277</td>
<td>0.00</td>
<td>100.00</td>
<td>0.00</td>
<td>7</td>
</tr>
<tr>
<td>Benjamin</td>
<td>815</td>
<td>5.00</td>
<td>93.00</td>
<td>2.00</td>
<td>29</td>
</tr>
<tr>
<td>Calvin</td>
<td>446</td>
<td>0.22</td>
<td>99.77</td>
<td>2.00</td>
<td>15</td>
</tr>
<tr>
<td>Dwight</td>
<td>537</td>
<td>93.00</td>
<td>3.00</td>
<td>4.00</td>
<td>24</td>
</tr>
<tr>
<td>Franklin</td>
<td>471</td>
<td>11.00</td>
<td>74.00</td>
<td>15.00</td>
<td>22</td>
</tr>
<tr>
<td>Harry</td>
<td>317</td>
<td>0.00</td>
<td>100.00</td>
<td>0.00</td>
<td>13</td>
</tr>
</tbody>
</table>

Of the 110 participants, the AMSTI mathematics and science survey was administered to 95 participants. Fifteen participants either left the position due to county-wide layoffs or due to personal reasons. Of the 95 participants, 6 did not complete the surveys and no reasons were given. Therefore, this study was conducted with 89 participants. Seventeen Kindergarten teachers, 15 first grade teachers, 12 second grade teachers, 19 third grade teachers, 14 fourth grade teachers, and 12 fifth grade teachers constituted the population of the main study.

Description of AMSTI

This description of AMSTI is based on the researcher’s participation in the AMSTI training during the summer of 2009. The session was held in Tuscaloosa, Alabama, as part of The University of Alabama--University of West Alabama In-Service Center’s AMSTI training. All sessions were conducted at Central High School. The researcher attended year 2 training in mathematics and science. Year 2 is similar to year 1--the participants just work on different units in mathematics and science. Although the AMSTI training is for K-12 teachers, the researcher concentrated her observations and participation on the K-5 levels. The description that follows is
from the K-5 workshops. Each grade was housed in a separate classroom. The researcher was
able to rotate between the six classrooms during the mathematics training and then again during
the science training.

Professional development in AMSTI primarily occurs through a Summer Institute that
consists of 10 days of training in 2 consecutive weeks for two summer sessions. During the first
week of each summer session, participants receive professional development in mathematics
for 5 days, followed by a second week during which the same participants receive professional
development in science for 5 days.

The curriculum used for mathematics is *Investigations in Number, Data, and Space*
(*Investigations*) developed by Technical Education Research Center and partially funded by the
National Science Foundation. Each grade level has five books of lessons pertinent to that grade
level, which cover the main content areas of Number and Operations, Geometry, Measurement,
Data Analysis, and Probability.

In mathematics, the *Investigations* series is for Grades K-5. Each of the books for this
series has multiple lessons grouped by the main content area of the book. During the AMSTI
summer training, each participant is trained on several lessons for their grade level. Only certain
lessons are presented; thus there are several lessons in each book that never get covered. Every
day all the participants receive training in the same content area for their grade level (such as
data analysis). Different lessons from the same books are covered in year 1 training and year 2
training. Thus after two 2 years of training, participants are trained in multiple lessons for their
grade level; however, they do not get trained in all the *Investigations* lessons.

The curriculum used for science is the *Full Option Science System (FOSS)*, developed at
Lawrence Hall of Science, University of California, and *Global Observations and Learning to
Benefit the Environment (GLOBE). GLOBE is housed by the University of Corporation for Atmospheric Research, Colorado, and sponsored by the National Oceanic and Atmospheric Administration, NASA, the National Science Foundation, and the U.S. Department of State. Many other cooperating organizations work with GLOBE.

In science, the FOSS kits are the modules designed for Grades K-5. All teachers receive training in one science module pertaining to their grade level in year 1. In year 2, all teachers receive training in two different science modules. In addition, participants receive training on one GLOBE project per year. See Table 6 for a complete list of FOSS modules and GLOBE projects by grade level and year.

Table 6

**FOSS Modules and GLOBE Projects for Year 1 and Year 2**

<table>
<thead>
<tr>
<th>Grade</th>
<th>FOSS Year 1</th>
<th>GLOBE Year 1</th>
<th>FOSS Year 2</th>
<th>GLOBE Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>Trees</td>
<td>Weather</td>
<td>Living Things</td>
<td>Balls &amp; Ramps</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fill in the Holes</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Balance &amp; Motion</td>
<td>Animals 2x2</td>
<td>New Plants</td>
<td>Air &amp; Weather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Balancing &amp; Weighing</td>
<td>Fill in the Holes</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Solids &amp; Liquids</td>
<td>Balancing &amp; Weighing</td>
<td>Soils</td>
<td>Organisms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fill in the Holes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Plant Growth &amp; Development</td>
<td>Chemicals</td>
<td>Earth Materials</td>
<td>Human Body</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fill in the Holes</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Electric Circuits</td>
<td>Animal Studies</td>
<td>Motion &amp; Design</td>
<td>Physics of Sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fill in the Holes</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Variables</td>
<td>Microworlds</td>
<td>Ecosystems</td>
<td>Solar Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fill in the Holes</td>
<td></td>
</tr>
</tbody>
</table>
During the summer, professional development in AMSTI is conducted throughout the state in different locations. Specific schools are selected to participate in this program (based on an application procedure and availability at the AMSTI site servicing the school district). Initially, all participants from these schools assemble together at each site for about 1.5 hours for a brief introduction describing the history and progress of AMSTI. Teachers are then grouped according to their year of training (year 1 or 2) and specific grade level for the remainder of their 2-week training. The leaders of each grade level session are called “trainers.”

The trainers are practicing classroom teachers who have been through the AMSTI mathematics and science training for certification. After implementing AMSTI at least one year, they qualify to attend Train the Trainer sessions sponsored by the State Department of Education (SDE). These sessions are by invitation only and based on recommendations of area mathematics and science specialists and school principals. Sessions are held at central locations around the state and generally last 2 days. These training sessions are facilitated by certified trainers or specialists from the Alabama State Department of Education.

*AMSTI Mathematics Training*

The sessions for Summer 2009 in Tuscaloosa were conducted by trainers who were currently teaching the same grade level as the AMSTI workshop grade level they were presenting. All trainers at the elementary level for the Tuscaloosa workshops were females. The trainers had a specific agenda for each day. A sample day’s agenda is found in Appendix C. There were several of the AMSTI workshops being conducted throughout the state at various locations and various times, during the summer of 2009. Some workshops used the same trainers. Although there were several workshop trainers available for each grade level, they all
taught from the same lesson plans (agendas). All trainers had received training on how to conduct each day of the workshop.

On the first day, participants were given a three-ring binder that consisted of articles related to mathematics teaching, a copy of the 2003 *Alabama Course of Study: Mathematics*, copies of activities that could be taught during the week, number cards, hundreds charts, and games ready for use in the classrooms. The articles presented effective ways of questioning, writing in mathematics, use of literature in mathematics, realistic problem solving, and reform in mathematics teaching.

Typically, the day started with a graphing activity that involved all the participants in the room. Data were gathered from real life situations such as color of clothes, birthdays, birthdates, etc. The data were then posted on charts, usually with sticky notes. Then questions were raised and answered based on the data. Participants had to keep a daily journal and were encouraged to represent data in their journals in two or more ways. The focus of this activity was data collection and analysis in a collaborative fashion and how such data can be represented in different ways. The data collection was followed by a PowerPoint presentation on the focus topic of the day, such as number and operations, geometry, probability, data analysis, or algebra. The concept of the day was developed through discussions, journal writing, and hands-on activities (from *Investigations*). The trainer walked the teachers through each activity and discussed the various ways the trainer had used the activity in her classroom, as well as any problems that might occur.

Next the trainer showed participants how to use the *Investigations* book. The book explained the time required for each lesson, materials, and preparation required for the lesson. When the trainer decided the teachers understood how to use the book, the trainer selected
another lesson from the book and the participants worked through it as a whole group. Different forms of assessment for the lesson were discussed and how the lesson related to the 2003 *Alabama Course of Study: Mathematics* was clearly articulated. Later, a video on an effective teaching strategy was played and a group discussion of it took place. Each day a different strategy was presented and discussed. This concluded the afternoon session. Each day a major content area was covered; however, the format of each day was very similar over the 5 days of training.

Toward the end of the mathematics workshop, math specialists who were employed full time by AMSTI visited each individual workshop and asked questions about the day and the professional development the participants had received. These specialists were teachers who had practiced inquiry-based teaching and were helping the trainers to train the participants. They provided curriculum support, clarified procedures related to materials, and bonded with teachers to establish a support role in the classroom after school begins. These math specialists would be coming to the teachers’ classroom during the year to provide additional assistance.

When the participants completed their 5 days of mathematics training, they received all of the resources, pertinent to their grade level, needed to implement *Investigations* in their classroom. These resources were the *Investigations* books ready-to-use manipulatives; *Investigations* manipulatives; game cards; two children’s literature books that could be used to introduce mathematics in classroom, such as *The Greedy Triangle* and *Grandfather Tang’s Story*; and a CD which had the .pdf format of the worksheets and some templates required for AMSTI mathematics activities. The participants were given materials at the workshop and allowed to keep them in their classroom until they were no longer employed by the school.
system. If they left the school system they were to return all the mathematics materials to their AMSTI site.

**AMSTI Science Training**

The second week of AMSTI training in Tuscaloosa was the science training. Similar to the mathematics training, on the first day the participants were given a three-ring binder that consisted of research articles related to teaching science, the 2005 *Alabama Course of Study: Science*, copies of activities, and games ready for use in the classrooms. The articles presented effective ways of teaching science, journal writing in science, use of literature in science, inquiry-based learning, and reform in science teaching.

Typically, the day started with an experiment that came out of a *Foss* kits (e.g., plants, soils, solar energy, etc.). The trainer explained the use of the kit and how to use the teacher resource guide for teaching the specific topic. Sample kits were on each table and the participants worked in groups learning how to teach the topic. The trainer explained the different components of the kit and how they could be used effectively.

In the morning session, the trainer discussed the focus topic for the day and how they were going to study it. The trainer showed the participants how to make predictions, do observations, collect data, record data, and analyze data. Following this, the participants worked in groups and conducted the experiment. Discussions were encouraged among group members by the trainer. The participants recorded their predictions, observations, and data in their science journals. This was followed by a lunch break.

In the afternoon session, participants had to make conclusions based on the data they collected. After this, the trainer recorded the predictions, the method of conducting the study, and
the results of each group’s work. The participants saw different ways the experiment had traveled. This was followed by a general group discussion on the nature of science accompanied with a PowerPoint presentation. Later, a video of effectively teaching science through inquiry-based learning was viewed. After viewing, the trainer used the teachers’ guide to explain how this particular experiment aligned with 2005 *Alabama Course of Study, Science*. She also discussed performance assessment and how it could be done as students do the experiment, in addition to reading their science journals. This concluded the afternoon session, which was followed by a quick clean up. Two science modules were covered in the first 3 days. This was followed by training in one GLOBE project for the next 2 days.

A science specialist, who had been a classroom science teacher and practiced inquiry-based learning, came to visit the participants every day to find out how the sessions were going and to question-participants at random about the professional development offered. The role of the science specialists was to provide curriculum support, offer on-site support after the training, and clarify procedures related to materials. They also were to provide follow-up assistance to the participants in the upcoming school year. When the teachers completed their 5 days of science training, they were eligible to receive all of the resources needed to implement *the Foss kits* in their classroom. The materials consisted of the *FOSS* kits, which were ready to use experiments with all supplies needed and one children’s literature book that could be used to introduce science in the classroom.

In order for the participants to receive the science materials, AMSTI sends out a schedule for the year which includes four delivery and pick-up cycles for the AMSTI science modules. Once the modules arrive at the school office, classroom teachers are responsible for pick-up and delivery from the office. They must return the kits to the office when they are finished so the kits
can be refurbished for other teachers. These modules are picked up by AMSTI and taken to the
warehouse for refurbishment and then sent out to other classrooms.

In addition to the science modules, equipment needed for implementing the GLOBE project is delivered to each school system. The classroom teachers are expected to share and use the GLOBE materials provided. Similar to the FOSS kits, GLOBE materials are returned to AMSTI, refurbished, and sent out to other teachers.

Instrumentation

This is a mixed methods study using four data sources. These sources are (a) the AMSTI Mathematics Questionnaire (Appendix D), (b) the AMSTI Science Questionnaire (Appendix E), (c) open-ended questions (Appendix F), and (d) focus group interviews (Appendix G). The AMSTI Mathematics and Science Questionnaires were used to gather information on training, implementation, and practices. Also, an interview protocol was developed to get more in-depth answers on training, implementation, and practices.

AMSTI Mathematics Questionnaire

The mathematics questionnaire consisted of 22 items using a 4-point Likert-type scale. The original Mathematics Questionnaire was developed by Sherry Kelley in 2007 as part of her dissertation but was used with first-year AMSTI trained teachers at the elementary level (Kelley, 2007). In order to use the same instrument with second-year AMSTI trained teachers, the pilot study was done to determine that it was reliable and valid.
AMSTI Science Questionnaire

The AMSTI Science Questionnaire was developed by the researcher. It paralleled the Mathematics AMSTI Questionnaire with adaptations made in two questions. Question 12 was changed from “As a result of AMSTI training, I spend more time on using inquiry learning approaches than before the training” to “As a result of AMSTI training, I spend more time using inquiry (problem solving) approaches than before the training.” The term “problem solving” was added to explain inquiry better. Question 13 was changed from “As a result of AMSTI training, I spend less time on memorization skills than before the training” to “As a result of AMSTI training, I spend less time on memorization than before the training.” The word “skills” was eliminated in the revised format. The AMSTI Science Questionnaire consisted of 22 items using a 4-point Likert-type scale. In addition to the 22 items on each questionnaire, there were five open-ended questions concerning AMSTI mathematics and science used to gather more in-depth information from the participants. The pilot study established the reliability and validity of the science questionnaire.

Interviews

The interview protocol was developed by the researcher to gather additional information about the perceptions of the participants about AMSTI mathematics and science training, implementation, and practices. The interview questions in mathematics and science were developed with prompts to complement the quantitative data and get a comprehensive understanding of the teachers’ perceptions. In addition, these questions were developed to gather information that would provide insights about AMSTI as a professional development program. The purpose of the interview, according to Patton (1990), is to allow the interviewer to enter into
another person’s perspective to find out what is in someone else’s mind. These interviews could allow the participants to provide detailed accounts on the topic at issue. Interviews provide immediate feedback, permit the interviewee to follow up on leads, and obtain additional data to enhance clarity (Tuckman, 1999).

Design of the Study

The surveys were administered during faculty meetings at the six selected schools. The researcher explained the study, got the approval of the teachers in the consent form, and stepped out of the room. After 15 minutes, she collected the surveys. After analyzing the demographic data in the survey and the willingness of the participants to be interviewed, six focus group interviews were set up, one at each school. Each interview lasted approximately for 30 minutes. Consent to tape the interview was obtained before the interview started. The use of a tape recorder has several advantages in recording the interview data for research. It reduces the tendency of interviewers to make an unconscious selection of data favoring their biases, and it is also possible to analyze the taped interview data to test hypotheses not considered for original study. Also, tape-recording the interview serves various purposes in understanding the research.

Member Checking

Member checking is done to represent the reality as constructed by the individuals who were studied (Gall, Gall, & Borg, 2003). In this process, the participants review statements made in the researchers’ reports for accuracy and completeness. Member checking can reduce the occurrence of incorrect data as well as incorrect interpretation of data. Member checking was completed at the end of the study to increase credibility. The researcher sent all of the data to the
participants of each interview in the study. The participants reported that the interview transcriptions reflected their views.

Data Analysis

A mixed methods design was used in this study to address the research questions. Quantitative methods were used to address Research Questions 1, 2, and 3, and qualitative methods were used to measure Research Questions 4 and 5. Creswell (2007) considers mixed methods research where quantitative data is used to develop qualitative data as a practice that provides deep understanding. Creswell offers mixed methods as an appropriate research strategy as a way to improve on the use of qualitative or quantitative data. In Creswell’s view, mixed methods are more comprehensive, encourage collaboration and deliberate incorporation of more than one worldview, and are especially suited for situations where practicality and pragmatism are prized (Creswell, 2007).

Research Questions 1, 2, and 3 addressed the perceptions of training, implementation, and practices of the mathematics and science components of AMSTI. Research Question 1 was analyzed using mixed factorial ANOVA with mathematics and science scores as the within subjects (repeated) variable and the grade level as the independent variable. Research Questions 2 and 3 were analyzed using descriptive statistics (i.e., percentages).

Research Questions 4 and 5 addressed the changes elementary teachers made in teaching mathematics and science as a result of AMSTI training and were analyzed qualitatively through open-ended questions and focus group interviews. The open-ended responses in mathematics and science were read and categorized. In addition, six focus groups interviews were conducted with 13 participants at six different schools representing teachers’ different grade levels to get
in-depth knowledge about the teachers’ perceptions of AMSTI mathematics and science and its impact on instructional strategies in the classroom. Then, the interviews were transcribed. Following transcription, these transcribed interviews were sent to the participants for member checking via email. The participants reported the transcriptions accurately reflected what they stated during the interviews.

After receiving responses from all of the focus group interview participants, the six interview transcriptions were carefully read and categorized using Shank’s (2002) thematic analysis. Next, similar categories were grouped together and themes were found. As the themes began to emerge, they were highlighted with specific colors. Next, all similar colored categories were put together in mathematics and science sections. Later, dominate similar categories between the two data sets were determined. Finally as these similar categories were organized, themes were found. These themes were analyzed and constituted the data for the qualitative section of this study.

Shank (2002) described coding as the process of identifying and labeling small portions of information to develop categories or themes. Shank also defined qualitative research as “[a] form of systematic empirical inquiry into meaning” (p. 5). This approach, also known as the emergent thematic analysis approach, involves searching for patterns within the data to analyze the findings.

The purpose of interviews is to gather additional data about the perceptions and impact of AMSTI training in mathematics and science in their classroom and their professional preparation for teaching it through AMSTI Summer Institute. Triangulation of data was used with quantitative data, open-ended questions, and focus group interviews. According to Merriam
(1998), multiple sources of data are used to confirm the emerging findings, and Patton (1990) recommends triangulation of data for checking the consistency of the varied data sources.
CHAPTER IV
ANALYSIS OF DATA

Introduction

In this chapter, the results are presented from the analyses of the perceptions of elementary teachers regarding their perceptions of the mathematics and science training and implementation of a state mandated professional development for classroom teachers, the Alabama Math, Science, and Technology Initiative (AMSTI). The AMSTI mathematics questionnaire and science questionnaire were administered to 89 K-5 teachers who took part in Year 2 of AMSTI training during the summer of 2009. These teachers taught using the AMSTI mathematics and science materials during the year 2009-2010 academic year. In addition, six focus group interviews were conducted with 13 teachers. Pseudonyms were used to protect participants’ anonymity. Data were analyzed to answer five research questions.

Results by Research Question

Research Question 1

Is there a difference in second-year K-5 teachers’ perceptions in AMSTI training, implementation, and practices in mathematics and science across grade levels?

Research Question 1 examined whether there were any differences among second-year AMSTI trained K-5 teachers based on grade levels of teachers in mathematics and science on three components: training, implementation, and practices. These components were derived from principal components analyses in the pilot studies. Data sources were Likert-type items on
mathematics and science surveys. Mixed factorial ANOVA was used to analyze the data with mathematics and science scores as the within subjects (repeated) variable and the grade level was the independent variable. ANOVA results show there is a significant difference in the perceptions of mathematics and science training, implementation, and practices in Grades 2, 3, and 5. The overall results for training are presented in Tables 7 and 8, then the overall results for practices are presented in Tables 9 and 10, and, finally, the overall results for implementation are presented in Tables 11 and 12.

**Training.** The ANOVA summary table for AMSTI mathematics and science training is presented in Table 7. Means and standard deviations for mathematics and science training across grade levels are presented in Table 8.

Table 7

*ANOVA for Mathematics and Science Training*

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>2.86</td>
<td>1</td>
<td>2.87</td>
<td>29.99**</td>
</tr>
<tr>
<td>Grade</td>
<td>.90</td>
<td>5</td>
<td>.18</td>
<td>.64</td>
</tr>
<tr>
<td>Training * Grade</td>
<td>2.17</td>
<td>5</td>
<td>.43</td>
<td>4.54*</td>
</tr>
</tbody>
</table>

*p < .01

**p < .001

Table 8

*Means in Mathematics and Science Training for Grades 2, 3, and 5*

<table>
<thead>
<tr>
<th></th>
<th>2nd Grade</th>
<th></th>
<th>3rd Grade</th>
<th></th>
<th>5th Grade</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
<td>N</td>
</tr>
<tr>
<td>Science</td>
<td>3.45</td>
<td>.39</td>
<td>12</td>
<td>3.55</td>
<td>.38</td>
<td>19</td>
</tr>
<tr>
<td>Mathematics</td>
<td>3.01</td>
<td>.27</td>
<td>12</td>
<td>3.04</td>
<td>.38</td>
<td>19</td>
</tr>
</tbody>
</table>
ANOVA results indicate a significant interaction effect between training and grade, $F(5, 83) = 4.54, p = .001$. There was a significant main effect for training, $F(1, 83) = 29.99, p < .001$. The grade level main effect was not significant, $F(5, 83) = .64, p = .673$. Post hoc pairwise comparisons using Bonferoni adjustment ($p < .008$) for the interaction effect indicated the mean scores in science training were significantly higher than the mathematics training mean scores in Grades 2, 3, and 5. The mean value of second grade science training was 3.45, and the mean for mathematics training was 3.01 ($p < .001$); the mean value for third grade science training was 3.55, and for mathematics training was 3.04 ($p < .001$); the mean value for fifth grade science training was 3.40 and for mathematics training was 3.04 ($p = .005$).

*Practices.* The ANOVA summary table for AMSTI mathematics and science practices is presented in Table 9. Means and standard deviations for mathematics and science training across grade levels are presented in Table 10.

Table 9

*ANOVA for Mathematics and Science Practices*

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practices</td>
<td>7.35</td>
<td>1</td>
<td>7.35</td>
<td>107.01**</td>
</tr>
<tr>
<td>Grade</td>
<td>.92</td>
<td>5</td>
<td>.19</td>
<td>.62</td>
</tr>
<tr>
<td>Practices * Grade</td>
<td>.60</td>
<td>5</td>
<td>.12</td>
<td>.14</td>
</tr>
</tbody>
</table>

**$p < .001$**

Table 10

*Means in Mathematics and Science Practices*

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>3.39</td>
<td>.42</td>
<td>89</td>
</tr>
<tr>
<td>Mathematics</td>
<td>2.99</td>
<td>.42</td>
<td>89</td>
</tr>
</tbody>
</table>
ANOVA results show the interaction between practices and grade was not significant, 
\( F(5, 83) = 1.73, p = .137 \). There was a significant difference in practices, 
\( F(1, 83) = 107.02, p < .001 \). The grade level results were not significant, 
\( F(5, 83) = .62, p = .684 \). The overall mean value for science practices was 3.39 and the overall mean for mathematics practices was 2.99 
\( (p < .001) \). Science practices mean scores were significantly higher overall than the mathematics practice mean scores.

**Implementation.** The ANOVA summary table for AMSTI mathematics and science implementation is presented in Table 11. Means and standard deviations for mathematics and science training across grade levels are presented in Table 12.

Table 11

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation</td>
<td>.82</td>
<td>1</td>
<td>.82</td>
<td>13.57**</td>
</tr>
<tr>
<td>Grade</td>
<td>1.32</td>
<td>5</td>
<td>.26</td>
<td>.93</td>
</tr>
<tr>
<td>Implementation * Grade</td>
<td>1.25</td>
<td>5</td>
<td>.25</td>
<td>4.13*</td>
</tr>
</tbody>
</table>

*p < .01

**p < .001

Table 12

<table>
<thead>
<tr>
<th></th>
<th>3rd Grade</th>
<th>5th Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Science</td>
<td>3.52</td>
<td>.39</td>
</tr>
<tr>
<td>Mathematics</td>
<td>3.27</td>
<td>.30</td>
</tr>
</tbody>
</table>
ANOVA results indicate a significant interaction between implementation and grade, $F(5, 83) = 4.13, p = .002$. There was a significant main effect in implementation, $F(1, 83) = 13.57, p < .001$. The grade level results were not significant, $F(5, 83) = .93, p = .46$. Post hoc pairwise comparisons using Bonferroni adjustment ($p < .008$) for the interaction effect indicated the mean scores in science implementation were significantly higher than the mathematics implementation means scores in Grades 3 and 5.

The mean value for third grade in science implementation was 3.52, the mean for mathematics implementation was 3.27 ($p < 0.002$), the mean value for fifth grade science implementation was 3.47, and for mathematics implementation was 3.13, ($p < .001$). This indicates there were significant differences in implementing mathematics and science in Grades 3 and 5, with science having significantly higher scores.

**Research Question 2**

What are the second-year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in mathematics?

Research Question 2 examined K-5 teachers’ perceptions of AMSTI mathematics training after 2 years of participating in a statewide initiative. Data sources were Likert-type items on the mathematics survey. The three components as identified by the pilot study were training, implementation, and practices. A total of 89 participants completed the survey. Means and standard deviations for mathematics training by grade level are presented in Table 13. In addition, percentages for survey items by components are presented in Table 14.
Table 13

Means and Standard Deviations for Mathematics Training

<table>
<thead>
<tr>
<th>Component</th>
<th>Grade</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>K</td>
<td>3.39</td>
<td>.42</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3.08</td>
<td>.46</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.01</td>
<td>.27</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.03</td>
<td>.38</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.07</td>
<td>.54</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.04</td>
<td>.61</td>
<td>12</td>
</tr>
<tr>
<td>Implementation</td>
<td>K</td>
<td>3.45</td>
<td>.36</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3.21</td>
<td>.40</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.40</td>
<td>.42</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.27</td>
<td>.30</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.13</td>
<td>.45</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.13</td>
<td>.55</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.27</td>
<td>.42</td>
<td>89</td>
</tr>
<tr>
<td>Practices</td>
<td>K</td>
<td>3.04</td>
<td>.45</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2.98</td>
<td>.34</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.03</td>
<td>.55</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.03</td>
<td>.36</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2.89</td>
<td>.39</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2.96</td>
<td>.53</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.99</td>
<td>.42</td>
<td>89</td>
</tr>
</tbody>
</table>
### Table 14

**Percentages for Mathematics Likert-type Survey Items (N = 89)**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component I: Training</th>
<th>SD</th>
<th>D</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Training at the 2009 Summer Institute prepared me for successful implementation of the AMSTI mathematics activities</td>
<td>0</td>
<td>5</td>
<td>65</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Participation in hands-on learning activities in 2009 Summer Institute was important for successful implementation of the AMSTI mathematics activities</td>
<td>2</td>
<td>6</td>
<td>57</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>I feel confident in my ability to manage the AMSTI mathematics manipulatives when implementing the activities</td>
<td>0</td>
<td>12</td>
<td>58</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>I feel comfortable asking the AMSTI math specialist to work with me</td>
<td>1</td>
<td>16</td>
<td>63</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>Collective participation by our school faculty provides a strong support system for implementation of the AMSTI mathematics activities</td>
<td>1</td>
<td>12</td>
<td>62</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>I was able to implement as much of AMSTI mathematics curriculum as was asked of me at the 2009 Summer Institute</td>
<td>5</td>
<td>33</td>
<td>44</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component II: Implementation</th>
<th>SD</th>
<th>D</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>The manipulatives provided by AMSTI are adequate for implementation of the AMSTI mathematics activities</td>
<td>0</td>
<td>2</td>
<td>60</td>
<td>38</td>
</tr>
<tr>
<td>9</td>
<td>The learning needs of students of different abilities can be met through AMSTI mathematics activities</td>
<td>0</td>
<td>6</td>
<td>60</td>
<td>34</td>
</tr>
<tr>
<td>11</td>
<td>My school’s administration is supportive of my implementation of AMSTI mathematics activities</td>
<td>0</td>
<td>5</td>
<td>54</td>
<td>41</td>
</tr>
<tr>
<td>18</td>
<td>As a result of AMSTI training, I use more effective questioning during mathematics instruction than before the training</td>
<td>1</td>
<td>8</td>
<td>72</td>
<td>19</td>
</tr>
<tr>
<td>19</td>
<td>I believe that teaching with the AMSTI materials has been beneficial to my students’ understanding of mathematics</td>
<td>0</td>
<td>3</td>
<td>64</td>
<td>33</td>
</tr>
<tr>
<td>20</td>
<td>Because of AMSTI training, I am more effective as a mathematics teacher</td>
<td>1</td>
<td>11</td>
<td>58</td>
<td>30</td>
</tr>
<tr>
<td>21</td>
<td>My students show an increased interest and motivation to learn mathematics when participating in AMSTI activities</td>
<td>0</td>
<td>6</td>
<td>60</td>
<td>34</td>
</tr>
<tr>
<td>22</td>
<td>Overall, I think AMSTI promotes an effective way to teach mathematics</td>
<td>0</td>
<td>3</td>
<td>60</td>
<td>37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component III: Practices</th>
<th>SD</th>
<th>D</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>As a result of AMSTI training, I spend more time guiding students in working cooperatively than before the training</td>
<td>1</td>
<td>17</td>
<td>64</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>As a result of AMSTI training, I spend more time developing students’ conceptual understanding than before the training</td>
<td>1</td>
<td>16</td>
<td>63</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>As a result of AMSTI training, I spend more time on problem solving than before the training</td>
<td>3</td>
<td>18</td>
<td>60</td>
<td>19</td>
</tr>
<tr>
<td>13</td>
<td>As a result of AMSTI training, I spend less time on computation skills than before the training</td>
<td>14</td>
<td>46</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>14</td>
<td>Training at the 2009 Summer Institute covered the content knowledge and pedagogy necessary for implementing the activities</td>
<td>0</td>
<td>6</td>
<td>73</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>As a result of AMSTI training, I use a greater variety of assessment strategies in mathematics than before the training</td>
<td>1</td>
<td>17</td>
<td>63</td>
<td>19</td>
</tr>
<tr>
<td>16</td>
<td>As a result of AMSTI training, I encourage my students to discuss their thinking to help them make sense of mathematics more often than before the training</td>
<td>0</td>
<td>8</td>
<td>67</td>
<td>25</td>
</tr>
<tr>
<td>17</td>
<td>As a result of AMSTI training, I include more hands-on activities than before the training</td>
<td>0</td>
<td>7</td>
<td>53</td>
<td>40</td>
</tr>
</tbody>
</table>
The first component was training. Six Likert-type questions in the survey were data sources for AMSTI mathematics training. To further analyze the data, the categories of agree and strongly agree were combined, as were the categories of disagree and strongly disagree. If the teachers agreed or strongly agreed with an item, this indicated a positive perception of the training. If they disagreed or strongly disagreed, this indicated a negative perception of the training. The range of the items was from 63% to 95% in the agree/strongly agree category. This indicated that the teachers had positive perceptions of the training they received in AMSTI mathematics.

The next component was implementation. Eight Likert-type items in the survey were data sources for this question. The categories of agree and strongly agree were combined and so were the categories of disagree and strongly disagree. If the teachers agreed or strongly agreed with an item, this indicated a positive perception of implementation. The range of the items was from 91% to 98% in the strongly agree/agree category. This indicated that the teachers had very positive perceptions of the science implementation in the AMSTI program.

The final component was practices. Eight Likert-type items in the survey were data sources. The categories of agree and strongly agree were combined and so were the categories of disagree and strongly disagree. If the teachers agreed or strongly agreed with an item, this indicated a positive perception of practices. Seven of the eight items ranged from 79% to 93%. However, item 13 yielded more negative responses than positive. Overall, in the component of practices in mathematics, the teachers’ perceptions were positive. The one item that showed negative results was that the time teachers spent on computation was not reduced as a result of AMSTI.
Research Question 3

What are second-year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in science?

Research Question 3 examined K-5 teachers’ perceptions of AMSTI science training after 2 years of participating in a statewide initiative. Data sources were 22 Likert-type items on the science survey and open-ended questions. The components as identified by the pilot study were practices/implementation and training. A total of 89 participants completed the survey. Means and standard deviations for science training by grade level are presented in Table 15. In addition, percentages for survey items by components are presented in Table 16.

Table 15

*Means and Standard Deviations for Science Training*

<table>
<thead>
<tr>
<th>Component</th>
<th>Grade</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>K</td>
<td>3.29</td>
<td>.38</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3.19</td>
<td>.45</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.45</td>
<td>.40</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.56</td>
<td>.39</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.30</td>
<td>.38</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.40</td>
<td>.50</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.37</td>
<td>.42</td>
<td>89</td>
</tr>
<tr>
<td>Implementation /</td>
<td>K</td>
<td>3.27</td>
<td>.40</td>
<td>17</td>
</tr>
<tr>
<td>Practices</td>
<td>1</td>
<td>3.28</td>
<td>.47</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.55</td>
<td>.42</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.53</td>
<td>.39</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.30</td>
<td>.38</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.48</td>
<td>.48</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.40</td>
<td>.43</td>
<td>89</td>
</tr>
</tbody>
</table>
### Table 16

**Percentages for Science Likert-type Survey Items Responses**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component I: Practices/Implementation</th>
<th>SD</th>
<th>D</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>As a result of AMSTI training, I spend more time guiding students in working cooperatively than before training</td>
<td>0</td>
<td>3</td>
<td>58</td>
<td>39</td>
</tr>
<tr>
<td>6</td>
<td>As a result of AMSTI training, I spend more time developing students’ conceptual understanding than before the training</td>
<td>1</td>
<td>2</td>
<td>62</td>
<td>35</td>
</tr>
<tr>
<td>7</td>
<td>The materials provided by AMSTI are adequate for implementation of the AMSTI science activities</td>
<td>0</td>
<td>0</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>9</td>
<td>The learning needs of the students of different abilities can be met through AMSTI science activities</td>
<td>0</td>
<td>0</td>
<td>57</td>
<td>43</td>
</tr>
<tr>
<td>12</td>
<td>As a result of AMSTI training, I spend more time using inquiry (problem solving) approaches than before the training</td>
<td>1</td>
<td>2</td>
<td>59</td>
<td>38</td>
</tr>
<tr>
<td>14</td>
<td>Training at the 2009 Summer Institute covered the content knowledge and pedagogy necessary for implementing the practices</td>
<td>0</td>
<td>1</td>
<td>60</td>
<td>39</td>
</tr>
<tr>
<td>15</td>
<td>As a result of AMSTI, I use a greater variety of assessment strategies in science than before the training</td>
<td>0</td>
<td>3</td>
<td>61</td>
<td>36</td>
</tr>
<tr>
<td>16</td>
<td>As a result of AMSTI training, I encourage the students to discuss their thinking to help them make sense of science concepts more often than before the training</td>
<td>1</td>
<td>0</td>
<td>58</td>
<td>41</td>
</tr>
<tr>
<td>17</td>
<td>As a result of AMSTI training, I include more hands-on activities before than the training</td>
<td>1</td>
<td>0</td>
<td>53</td>
<td>46</td>
</tr>
<tr>
<td>18</td>
<td>As a result of AMSTI training, I use more effective questioning during science instruction than before the training</td>
<td>1</td>
<td>0</td>
<td>64</td>
<td>35</td>
</tr>
<tr>
<td>19</td>
<td>I believe that teaching with AMSTI materials has been beneficial to my students’ understanding of science</td>
<td>0</td>
<td>0</td>
<td>52</td>
<td>48</td>
</tr>
<tr>
<td>20</td>
<td>Because of AMSTI training, I am more effective as a science teacher</td>
<td>0</td>
<td>2</td>
<td>61</td>
<td>37</td>
</tr>
<tr>
<td>21</td>
<td>My students show an increased interest and motivation to learn science when participating in AMSTI activities</td>
<td>0</td>
<td>0</td>
<td>49</td>
<td>51</td>
</tr>
<tr>
<td>22</td>
<td>Overall, I think AMSTI promotes an effective way to teach science</td>
<td>0</td>
<td>0</td>
<td>48</td>
<td>52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component II: Training</th>
<th>SD</th>
<th>D</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Participation in hands-on learning activities at the 2009 Summer Institute was important for successful implementation of the AMSTI science activities</td>
<td>0</td>
<td>1</td>
<td>54</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>I feel confident in my ability to manage the AMSTI science kits when implementing the activities</td>
<td>0</td>
<td>3</td>
<td>60</td>
<td>37</td>
</tr>
<tr>
<td>5</td>
<td>I feel comfortable asking the AMSTI science specialist to work with me</td>
<td>1</td>
<td>0</td>
<td>53</td>
<td>46</td>
</tr>
<tr>
<td>8</td>
<td>Collective participation provided by our school faculty provides a strong support for implementation of the AMSTI science activities</td>
<td>0</td>
<td>1</td>
<td>56</td>
<td>43</td>
</tr>
<tr>
<td>10</td>
<td>I was able to implement as much of the AMSTI science curriculum as was asked of me at the 2009 Summer Institute</td>
<td>2</td>
<td>12</td>
<td>56</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>My school’s administration is supportive of my implementation of AMSTI science activities</td>
<td>0</td>
<td>0</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>13</td>
<td>As a result of AMSTI training, I spend less time on memorization than before the training</td>
<td>1</td>
<td>3</td>
<td>62</td>
<td>34</td>
</tr>
</tbody>
</table>
The first component was practices/implementation. There were 14 Likert-type survey questions that addressed this component. To further analyze the data, the categories of agree and strongly agree were combined as were the categories of disagree and strongly disagree. If the teachers agreed or strongly agreed with an item, this indicated a positive perception of the practices/implementation. If they disagreed or strongly disagreed with an item, this indicated a negative perception of practices/implementation. The range of the items was 97% to 100% in the agree/strongly agree category. This indicated teachers had positive perceptions of AMSTI science practices/implementation.

The next component was training. The categories of agree/strongly agree were combined and the categories of disagree/strongly disagree were combined. When the teachers agreed/strongly agreed with an item it indicated a positive perception of the training, and when the teachers disagreed/strongly disagreed with an item, it indicated negative perceptions of the training. The range of the items was 96%-100% and all items were positive. This indicated the teachers had very positive perceptions of the AMSTI science training during the Summer Institute.

Research Question 4

What are second-year AMSTI trained K-5 teachers’ perceptions of AMSTI mathematics?

Research Question 4 addressed K-5 teachers’ perceptions in mathematics that occurred as a result of AMSTI mathematics training. Data sources were open-ended questions on a survey and focus group interviews. First, the open-ended questions were read and categorized. Then the focus group interviews were transcribed, coded, and categorized. The researcher then looked for dominate similar categories between the two data sets. As the categories were further organized,
themes emerged. These themes were (a) communication, (b) mathematics teaching resources, and (c) time.

**Communication.** According to the data collected from the open-ended questions and the interviews, teachers suggested that students’ oral and written communication skills improved when they were doing AMSTI. This communication was seen in the form of journal writing, cooperative learning, and math centers.

In journal writing, students communicated with their teachers as well as with other students (as they shared and discussed their journal writing pieces). The teachers who were interviewed reported that reading the journals gave them a clear picture of the students’ understanding of the math concepts. A majority of the teachers reported that journal writing was often done with problem-solving activities and required the students to put their thoughts into words as they wrote in their journals. Journal writing often reflected students’ comprehension of math concepts as well as their representation skills.

Many of the K-1 teachers stated that the problem-solving writing activities in those grades consisted of students representing their thoughts with pictures, shapes, or stick figures. Students used this pictorial form of communication to express the way they understood the math concepts and solved problems. While reporting about the use of journal writing, a kindergarten teacher wrote, “I use journal writing everyday. Students solve word problems in their journals. I read the problem to students in groups. Students draw how they solved. Usually students draw stick figures or shapes.” Typically, students explained their drawings. In an interview a kindergarten teacher who expressed the importance of writing as well as oral discourse wrote,
Students draw in journals most of the time. Sometimes it is just lines and circles. Later I pick out journals at random and students speak about what they have in the journals. It is surprising to see and hear how this age group understands math concepts.

During the interviews, a first-grade teacher reported the use of both oral and verbal communication in journals: “Students draw in their journals to show they solved the problems. Some students also write numbers, but many students draw and talk about their pictures.”

A majority of the K-1 teachers also reported displaying students’ journals in the hallways. By doing so, students’ depictions and understanding of math concepts were known to all who crossed the hallway. A first-grade teacher wrote, “I make copies of students’ math journals and post them. It is a good exercise for students to represent their thoughts.” Kindergarten teachers wrote that students talked about the content of the displayed journals while entering and exiting the classrooms.

Teachers in Grades 3, 4 and 5 reported journal writing helped in improving students’ writing skills and meeting the ARMT (Alabama Reading and Mathematics Test) requirements. They also suggested that providing consistent writing opportunities helped in improving conceptual understanding of mathematics and also in helping to meet the Alabama Reading and Math Test (ARMT) requirements. The ARMT has a writing component which requires the students to show the work and/or explain their reasoning. Students are permitted to use drawings, words, and/or numbers. Students are expected to give written answers so that another person could read and understand it. Students are expected to show all their work. These results are used for accountability in Grades 3-8 for meeting one of the requirements of the No Child Left Behind legislation (Alabama State Department of Education, 2009).

Teachers (Grades 3-5) reported making use of journal writing as a daily practice to address this writing need concerning ARMT. A fourth-grade teacher reported using journal
writing four times a week due to the help it provides in problem solving and developing clarity in communicating how students solved problems. By writing in journals, students communicated their interpretations of the problems. She stated in the interview,

Students have to explain in words how they solved the problems. I get problems from various resource books such as ARMT samples, text book, enchanted learning etc., this writing exercise has helped extensively in ARMT and this is one thing I use from AMSTI training consistently. Close to testing time, we do more than one problem a day. I see how the students are reading and interpreting the problem and this helps me address the confusions students have in comprehending the problem.

A fifth-grade teacher stated the way he uses journal writing throughout the week in his classroom. He promoted oral discussions with the whole class about one problem every week and then graded students for independent problem solving and writing about their problem solving. He stated,

I use journal writing twice a week. It takes me time to get through all the answers--till almost Wednesday every week. On Thursday, I discuss the problem with the whole class and point them the main problems I see in their answers. On Friday, all students get a similar problem for their journal entry and they solve it- explain how they solved in steps- exactly the way ARMT folks want it. For the Friday writing students get a grade like they would get in ARMT anywhere between 1-4. One of the benefits of AMSTI training was providing us with journal prompts and showing us different ways to use journal writing in mathematics. After the training was over we received a CD with math games, worksheets, and one section with ideas for journal writing. I pull journal prompts from this CD.

Another area that showed evidence of communication was group work such as cooperative learning. Cooperative learning was reported to be used by K-4 teachers. In cooperative learning groups, teachers reported that students talked with each other and these conversations aided in knowing how other students understood the same math concept. A first-grade teacher who believed in the importance of oral communication in group tasks wrote,

I hear a lot of discussions during when students work together especially when it is a task like solving puzzles, completing the missing pattern etc., I go around the different groups and can see as well as listen to the different ways students are trying to do the task.
A second-grade teacher stated the use of oral and written communication in cooperative learning groups with an example from her class:

Students work in groups to solve number problems such as finding the missing numbers. Usually one side of the equation of a number sentence is missing. Students have to guess, check, and revise to get these answers. They have a sheet where they write down all the number sentences they could solve. This sheet tells me the combinations they used to get the answers. To do this lesson, students work together; move the number tiles, talk with each other, discuss what numbers have to be used to make the number sentence true, basically it is trial and error and figure out the number sentences. I typically have 10 number sentences for each group.

Second grade teachers considered group work as a reinforcing activity in which students help each other learn by showing their work and talking about it. One of the second-grade teachers wrote,

I did an *Investigations* lesson on different ways of adding up to $1.00. Students had money bags and worked in small groups. They were focused, wanted to find as many solutions as they could, so they were discussing among their group members and writing down different combinations they had come up with. Finally I got the answers form all the groups and we all discussed about the combinations where least number of coins were used, where most number of coins were used, what combinations have been used by most groups and the discourse went on for a long time. This lesson made the students think, record their thinking, work as a group, and discuss the similarities and differences between groups.

Second-grade teachers who believed cooperative learning was beneficial wrote, “students reciprocate their views in the groups when they all have to think together to do the task,” “students learn from each other while working and talking with each other,” and “I see when one student does not get the point, another student who got it explains the way he/she understood it.”

These teachers also reported the benefits of them talking to students in groups. One second-grade teacher wrote, “When students work in cooperative learning groups, I visit all the groups to see how they are doing the task, listen to the conversations in the group, and provide my help if one or more students need it.” Typically students came back to their seats after the
group work time was over and then there was a whole class discussion on what was done in each group.

A third-grade teacher believed oral communication she had in cooperative learning groups with students helped in making difficult concepts such as fractions simpler. This kind of discourse gave insight into students’ misconceptions if there were any:

Students were working with fraction tiles and counters after I introduced the concept. All of them did not get it right away, but at least one or two in each group got the point. I worked individually talking to each student in the group. I understood the confusions by seeing the way students used fraction tiles, listening to what they said, and talking to them about parts and whole in real world situations

Teachers in Grade 4 reported using cooperative learning to initiate discussions in the classroom. Two fourth-grade teachers who used cooperative learning stated the usefulness of cooperative learning and believed that coherent oral communication skills improved due to cooperative learning. A fourth-grade teacher wrote, “Students learn from each other during cooperative learning by observing, discussing, reciprocating, and listening to other members of the group.” According to one fourth-grade teacher, whole class discussions was promoted due to cooperative learning groups. She stated in an interview,

Some of the Investigations activities call for students working in small cooperative groups and discussing about the problems. This has promoted discussion in the classroom and how the different groups approach the problem. Such moments are engaging for all students alike.

Another fourth-grade teacher highlighted the importance of discussions while students solved non-routine problems. She believed problem-solving skills were enhanced when a group of students discussed solving non-routine problems. She wrote,

I give non-routine problems to groups of students every Friday afternoon. It is mostly story problems from the figure this out website. One example is the boat can hold a weight of so many pounds only. The weight of each person varies. They also have animals that need to cross. One of the ladies can not go without the cat. The cat and dog cannot go in the same trip. So, anyway students get together in their groups and find a
logical solution to such problems. Later one student form each groups reads their assigned problem to the whole class and explain how their group solved it. This particular group work on Friday’s has given me insights about students’ capacity to think out of the box, and it is fun for all alike.

None of the fifth-grade teachers reported using cooperative learning. They cited inadequacy of time and pressure to prepare students for the tests as the reasons for not using cooperative learning.

The other area that showed evidence of communication was math centers, which were used specifically by K-3 teachers. These teachers indicated when groups of students worked together they talked with each other and shared their work with other members in the group. One of the first-grade teachers stated,

When I do math centers, students sit in groups of 4 or 5. They have individual trays or worksheets to do. I can always see students showing their work to their neighbors in the group and also to me. Moreover, I pick students at random to show and talk how they did their trays to the whole class. Students enjoy doing this show and tell activity and it also gives me a view of how different students utilized the center.

Another third-grade teacher reported her students were looking forward to math centers as they had a chance to play math games and communicate with their group members while improving basic math skills such as addition. She stated,

The most popular center in my class this year is the game center. In this one center, I set up games such “Race to 100,” “Tens go fish” and have even number of students. The students choose their partners to play the games. Both students have to record the moves in the games. I see a lot of involvement in this center, and there is continuous writing, playing and talking about their moves. I collect all their work at the end of center time to read the recordings. Some students get the hang of it right away.

Teachers who used group work such as math centers reported that communication was evident as the students worked and talked together about the math concepts on which they were working. The teachers also wrote that math centers provided different ways of understanding the
same concept meeting the needs of all students. However, teachers in Grades 4 and 5 did not report using math centers.

*Mathematics teaching resources.* The second theme was mathematics teaching resources. These resources consisted of manipulatives, math games, a CD of worksheets that accompanied the games, and the *Investigations* books. One of the foci of the AMSTI professional development program is to provide resources and training to use all these resources. Both interviews and the open-ended comments provided data about teachers’ reporting the convenience of having all of the materials they needed to implement AMSTI, the fluency they developed during the training in using these materials, and the variety of ways these materials were used as they implemented AMSTI.

Teachers across all grade levels indicated having all the resources for the whole class was convenient for implementing AMSTI lessons. However, a majority of K-4 teachers wrote that materials such as manipulatives and math games played a vital role in implementing *Investigations* lessons, improved students’ involvement, acted as a tactile model, and held students’ span of attention for a longer time. This was not indicated by the Grade 5 teachers.

A majority of the K-1 teachers considered having the manipulatives in hand saved a lot of planning time. One of the first grade teachers wrote, “I received all the manipulatives and games that went with the *Investigations* activities. This is made it very easy to do the lessons; also I had more than enough for all students.” A kindergarten teacher expressed her views on the convenience of having materials for the whole class as she stated,

> I received plenty of manipulatives compared to the number of students in my class. Also at times I use the same manipulatives for different lessons. Since I had plenty, I could further put the extra ones in small Ziploc bags and label them for the lessons I was
planning to use the next week. It is nice that I do not have to spend time and money to get the materials for teaching the lessons

Another first-grade teacher stated having ready-to-go supplies for the whole class was one of the reasons for doing AMSTI mathematics. She wrote,

Most of the *Investigations* lessons which I do require manipulatives and other materials such as worksheets that go with games. That is the way we practiced in the training. Since I have all the materials I need and know how to use it with the lessons, I do only AMSTI lessons to teach math.

Consistent comments about the convenience of having manipulatives and materials were reported by a majority of K-1 teachers. Easy availability of the resources was one of the common reasons reported by a majority of these teachers to do AMSTI lessons in class.

The K-4 teachers also stated that training in using the manipulatives improved their fluency while implementing in their classrooms. A second-grade teacher wrote about her fluency in using the manipulatives as, “I use the manipulatives almost with every lesson in my class. I had the training necessary to use them and the more I use them, the more ways I figure out to use them.” In an interview, a third-grade teacher who believed the training to use the manipulatives helped her to understand the multiple ways of using the manipulatives stated,

Many ways to use the same manipulatives was demonstrated during the training. To give you one example, I learned to use the connecting cubes for lessons with addition, multiplication, fractions, and also data and probability during the training. I have divided the connecting cubes and put them in small Ziploc bags. After using the same manipulatives for multiple lessons, I see many more ways of using the connecting cubes.

A fourth-grade teacher who considered the training to use the resources as essential before using them in her class stated,

I am confident in using these manipulatives in my class since I used them extensively during the training. Due to the first-hand experience I had with these materials and working with other teachers in my grade level, I understood how to use these resources effectively and what happens when I do not use the resources such as manipulatives ineffectively. I tried all I could with these manipulatives before bringing it out with my students.
Further, K-4 teachers also discussed the various ways they used the resources. One of the kindergarten teachers commented during the interview about the multiple manipulatives she used and their applicability. She stated the manipulatives go well with all lessons:

I use all manipulatives in the kit--specifically the bear counters, attribute blocks--well all the manipulatives are user friendly and applicable to the way I teach math. These manipulatives help in holding the students’ attention for a longer period of time and after the lesson is done I let them play with it.

A second-grade teacher who utilized a variety of manipulatives and believed the use of manipulatives helped in establishing meaningful learning of concepts wrote,

I use everything in the kit. I use the cubes, number line, clocks, measuring tapes, and just about all of it. The manipulatives have improved student engagement and students find a lot more meaning to the concepts now. It is good to have enough for all.

A third-grade teacher who believed manipulatives and math games added to the fun in learning math stated,

I use manipulatives for math centers. They are very useful. Specifically I use connecting cubes, calculators, money bags, tiles, and thermometers. I also like the game cards “Tens go Fish,” “Race to 100”--they are a fun way of promoting basic computation skills.

A fourth-grade teacher who believed manipulatives helped to establish concrete learning experience stated,

I use 100’s charts, graphs, Venn diagrams, money bags, inch tiles, and fraction bars--all these have helped the students understand the concepts in a concrete way. Due to the training I am fluent in using these materials.

A majority of the fifth-grade teachers reported doing *Investigations* activities required planning and resources for the whole class. Although the fifth-grade teachers reported the convenience of having resources for the whole class, they also indicated using the resources sparingly due to the time constraints and the pressure to keep with the pacing guides.

In an interview with fourth and fifth grade teachers, one of the fourth grade teachers stated of all the resources she received she used only the game cards “Guess my name” while
teaching the shapes. A fifth-grade teacher stated the convenience of having sets of resources for
the whole group although it is not always useful as she stated,

    I use calculators, charts, and graphs. At present I have calculators for all students since I
attended the training. That way, yes the training has been useful. But then, even though I
have all the resources, planning for *Investigations* activities takes up a lot of my time and
I do not have such time at present.

    The other teaching resource reported by a majority of teachers in the open-ended
questions and interviews was the *Investigations* teachers’ manuals. Although all teachers
reported they received *Investigations* teachers’ manuals along with training to use for all content
standards, teachers in Grades 4-5 reported they had difficulty following the *Investigations*
teachers’ manual. However, a majority of K-3 teachers had favorable comments about the
*Investigations* manuals they received and also about the training they received to use the
manuals. These teachers also believed practice with the *Investigations* manual helped in effective
use of the manual. One of the kindergarten teachers who developed fluency in using the manuals
wrote,

    I use *Investigations* lessons every day. The training to use these books was useful. I am
getting better in using these activities day by day. The more I do the activities, the more
comfortable I am in using various sections of the *Investigations* manuals.

    A majority of the Grade 5 teachers reported rarely using the *Investigations* manuals.
These resources were used as an enrichment activity rather than as part of their daily instruction,
as stated by majority of Grade 5 teachers. These teachers wrote that using the resources took
extra planning time when all of the objectives needed to meet the ACOS could be covered with
the regular textbook, which did not require as much planning time as the *Investigations* lessons.
However, they also wrote that the *Investigations* lessons helped understanding abstract concepts
whenever they used it.
Grades 4-5 teachers also considered *Investigations* manual as less user-friendly. A majority of these teachers expressed their displeasure in the layout of *Investigations* teachers’ manual. They considered it was time consuming and complex to figure out what sections of the manuals can be directly used while teaching math concepts. One of the fifth-grade teachers stated,

The *Investigations* manuals are not organized. I think there should be an index page which tells exactly where the activities are located for each standard--for instance let us take fractions--then it has to be listed where you have activities for addition, subtraction, mixed numbers, and other topics that go with fractions. The AMSTI *Investigations* manual needs more tweaking to grade-specific areas.

Another fourth-grade teacher expressed her displeasure of the *Investigations* manual by writing,

I think there has to be a guideline to match the pacing guides on where the activities are located in this book. This has to be laid out by seasoned teachers, university professors, and not AMSTI employed people. These books give a whole bunch of activities, some are useful and some are not. We need training in picking out the ones that apply to our classroom. Some are way over fourth grade, some are too time consuming, and some are just right. After 1 year I kind of know what to use and what not to touch.

All teachers in Grades K-3 had favorable views of all the resources they received, Grade 4 teachers had varied views about the resources, and Grade 5 teachers did not have favorable views of any of the resources but they acknowledged that they liked having enough materials for the whole class to use if they ever decided to use them. A majority of Grade 5 teachers reported not using most of the AMSTI resources because it required extra time to plan such lessons. In addition, they also reported not using the *Investigations* manuals due to its complex arrangement. However, teachers across all grade levels also mentioned they could improve time management skills with more practice of doing *Investigations* in their classrooms.
Time. The final theme was time. Even though all the interview participants reported that the mathematics training was useful, teachers in Grades 4-5 stated time was a determining factor in whether to implement the training they received or not. On the contrary, Grades K-3 reported having adequate time to implement the mathematics training they received. A kindergarten teacher stated, “I use *Investigations* everyday; and the *Investigations* book is full of fun and useful activities.” First and second grade teachers reported using *Investigations* at least four times a week. However as the grade levels increased, insufficient time was reported as a barrier to implementing *Investigations* lessons in the classrooms.

Although Grades 4-5 teachers wrote about spending more time in teaching mathematics on a daily basis, most of the time spent was devoted to improving computational skills and writing in mathematics and less time was devoted to teaching *Investigations* lessons. This also was evident from the open-ended responses and the focus group interviews with fourth and fifth grade teachers. One of the fourth grade teachers wrote time was an issue in her class because,

Really and truly I could do *Investigations* for 2-3 days in the beginning of the year. Later I could not do it since we are driven by tests every Friday. Moreover it is not easy for me to use the *Investigations* book and set up the classroom. I do not have time for such things in an already packed curriculum.

A fifth-grade teacher in the interview reported similar problems related to time by stating,

I do not have time to do the activities in the *Investigations* book though I know how to use it. What we teach is generally determined by the pacing guides and close to test time by the administration. We are under pressure to cover objectives which the students will be tested on. So, I do what has to be done for the benefit of the school. Moreover *Investigations* activities are time consuming, and require lot of planning. Also, I think students get the point when we follow our textbook and we have a workbook that reinforces and gives extra practice to the objectives we teach. It is not easy for me to use *Investigations* and I do not have the time for it in my present schedule.

The other fifth-grade teacher who had similar views commented that time as an issue because,

I am pressed by limited time and have to get through the main concepts matching the pacing guide. Again, the *Investigations* book is difficult to follow and takes a lot of my
time to figure out what I need to choose to match the ACOS and pacing guides. I have to find the activities that align with state standards. It is not worth spending time on such things when I am already pressed for time. Maybe experienced teachers could come together and pull out activities that are worth it and make a small usable *Investigations* book/manual matching the activities to the standards and pacing guide. I think this manual has to be revamped.

Grade K-3 teachers reported having enough time to implement the AMSTI mathematics training they had. However Grade 4-5 teachers reported time as a barrier to fully implement the AMSTI mathematics. A majority of these teachers mentioned adhering to pacing guides, getting students prepared to take the standardized tests, and showing adequate yearly progress for their grade level consumed all their time.

Research Question 5

What are the second-year AMSTI trained K-5 teachers’ perceptions of science?

This question addressed the K-5 teachers’ perceptions of changes in science. Data sources were open-ended questions on a survey and focus group interviews. First the open-ended questions were read and categorized. Then the focus group interviews were transcribed, coded, and categorized. Then the researcher looked for similar categories between the two data sets. Three themes emerged: (a) teaching strategies, (b) teaching resources, (c) and time.

*Teaching strategies.* From the data collected from open-ended questions and interviews, one of the themes that emerged was teaching strategies. These strategies were different from what the teachers had been using in their classrooms with science instruction. They reported that they were now using inquiry-based leaning and notebook writing. A second grade teacher wrote, “I spend more time in doing investigative lessons in science now and time in using textbooks.
Students do experiments in groups, have a tangible experience. We did the same too during the training and that has made it easy.”

Favorable comments about inquiry-based learning were given by the teachers during the interviews and in the open-ended questions. The teachers considered inquiry-based learning required more as hands-on learning, and working in groups. Due to this type of learning, students were more involved during science lessons.

A second-grade teacher wrote,

The experiments we do in the units are tangible. They talk about what it looks like, feels like, etc., and made remarks based on it. Science has become a subject that can be experienced and explored by students. I remember the unit on solids and liquids, when students learned the physical properties of solids and liquids. For liquids I used water, milk, and juice, and for solids I used pencils, pebbles, and sticks. The conversations I remember are “You need a container to hold water,” “The pebbles go down in water, milk, and juice,” “the pencil and sticks stays up in water, milk, and juice.” I used these remarks and asked them leading questions. Finding answers for all these questions took us to know the characteristics of solids and liquids. This lesson went for a longer time than I expected because of the experiences students had. They all understood the differences between solids and liquids in a tangible way. I added an extension lesson on float and sink since some students wanted to know why the pencil stayed up and the pebble went down.

Similar views about inquiry-based learning were given by some third grade teachers. They believed conducting experiments promoted students’ involvement and raised their curiosity, leading to questioning among themselves and in the whole class. In an interview, a third grade teacher stated,

Science is hands-on, and every experiment I have done so far is group work. I can give you an example when we studied about the growth of plants. All students grew their own plants in small cups. All supplies needed for this lesson was in the kit. Students recorded the observations of their plants for 10 days. I could hear students’ remarks such as “why does your plant have two leaves,” “What if I added more of water,” and “why is Joe’s plant the tallest in the class?” After all the recording of data was over, we used the students’ data to learn about the various stages of plant growth.
Another third grade teacher who reported that inquiry-based learning was making a difference wrote,

All science is group work now such as conducting experiments, making observations, recording data, coming to conclusions, and discussions based on findings--we all like science time now. After 2 years of teaching AMSTI science, I am getting better at handling group work.

Favorable comments on inquiry-based learning were reported by fourth and fifth grade teachers, also. A fifth-grade teacher who believed that inquiry-based learning was beneficial stated,

Students had to build an aquarium. All had identical items in their aquariums. They also had to make one hypothesis for each object inside their aquarium. They also had to make predictions of their aquarium’s condition after 2 weeks, then observe the living things and non-living things all the 2 weeks, record what happened to water everyday, how the living things and non-living things reacted for 2 weeks, what could be the reasons for the plants to grow inside the aquarium, reasons for water changing colors, and much more. This was a concrete learning experience about living and non-living things which required the students to use their skills in observation, make predictions, and understand the nature of living things. All students learned a whole lot by doing this 3-week long project

Another teaching strategy used in science was notebook writing. From the open-ended answers and interviews, the data showed that teachers used science notebooks in various ways to adapt the needs of the students. A majority of kindergarten teachers used class charts. Teachers in Grades 1 and 2 used individual science journals with words and pictures as prompts and teachers in Grades 3-5 followed the scientific method in using science notebooks, going through all the steps advocated for inquiry-based learning by National Science Education Standards.

A majority of kindergarten teachers mentioned they have class charts in lieu of individual science notebooks. These teachers also indicated all students go through the process of predicting, observing, collecting, recording, and drawing in the class chart. Also, these teachers
mentioned using class charts with every lesson taught. A kindergarten teacher who used class charts as a visual aid in doing experiments with the whole class wrote,

I use class charts with every group science lesson. This acts as a visual model. We log data and do picture graphs. I model how to log the data in the class chart. It is usually place stickers or make crayon markings in the chart. Students usually draw and there is no writing involved in my science class. We do a lot of discussing of why and how--it is more oral

A majority of teachers in Grades 1-3 reported using science notebooks. However Grade 1 teachers indicated modeling to use the science notebooks initially until the students became more independent. They also stated that they used prompts in the science notebooks which required students to use their senses to answer the questions or complete the sentence.

A first grade teacher stated in an interview:

I use science journals. I have prompts such as I see, I touch, I smell, I hear. I have these with dates and students draw pictures. When students answer these prompts they are forced to observe closely, feel, smell, and listen to it. I did a unit on Living things. I had plants in small tubs of water. I let the students feel, tear, smell, and see the plants. All the prompts related to the senses. I think students learned a lot of the physical properties of plants by tearing the plants apart, smelling them, feeling them. They were all completely involved in this lesson.

Teachers in Grades 4 and 5 reported using science notebooks consistently with inquiry-based learning. They believed students’ organization skills and responsibility to keep track of science notebooks were enhanced due to using science notebooks as an accompaniment to conducting experiments. A fourth grade teacher wrote, “Students are held accountable while and after doing the experiment since they are expected to report predictions, data, findings, and conclusions.” During the interview, another fourth-grade stated,

I do AMSTI science. Typically it is group work- similar to summer training I had. Students make predictions, collect data, record data, all this is done in groups--they have all this information in their science notebooks and they are graded at the end of the unit for a performance grade. After doing the experiments together, they move away from their groups and write down the procedures, their conclusions and why they think it happened this way. AMSTI science is a structured, engaging way to teach science.
Students now understand the vocabulary since I see them using in other subjects also—for instance I see more of words such as classified, symptoms, and much more. Since they have to put down all the information related to the experiment with date and time, I see clearly what each student has done every day.

Additionally, another fifth grade teacher who believed science notebooks helped improve logical and analytical thinking wrote, “Science notebooks have improved organization skills such as representing data in tables, graphs, and writing in general.” A majority of Grades 4-5 teachers believed that science notebooks were a complementary resource to the science kits and necessary to implement inquiry-based way of learning science. According to one fourth grade teacher, who believed science notebooks were equally as important as inquiry-based learning in science to develop analytical thinking skills,

I use writing in science notebooks extensively—we start recording predictions, data collection, drawing graphs, listing out what happened in the end why did this happen. I spend equal amount of time in science activities and science journals. I think this practice of writing in science is vital for conceptual understanding.

Similar comments were given by a fifth grade teacher who used a structured way of utilizing science notebooks and considered science notebooks helped in conceptual understanding:

I use science notebooks with every unit I teach. I have it well organized. Students are to list the materials used, time started, time finished—do a math problem on how much time the whole experiment took, list the predictions, make observations, tabulate the data, draw conclusions from data, explain why these results came about, and report everything in 1,2,3 format. This set-up took a long time to establish with the whole class. Since I go elaborate in the scientific method, I can cover only one unit per year. However, the one unit I teach, I go in-depth. After finishing the unit, we have a whole class discussion and all the concepts are meaningful.

Teaching resources. Another theme in the teachers’ perceptions of science was science teaching resources. The main resources mentioned by the teachers were FOSS kits, teachers’ manuals, and the GLOBE equipment. Teachers across all grade levels indicated the resources
they received such as FOSS kits along with the teachers’ manuals, and the training to implement the FOSS kits proved to be beneficial. In addition, all teachers were appreciative of having enough materials for all their students to use.

Teachers across all grade levels indicated that the FOSS kits with all of the components for each unit were essential in implementing inquiry-based learning. A kindergarten teacher wrote, “I use all science resources in the FOSS kit. I need all of it to teach the science lessons. It is easy to use and students enjoy it.” Another first grade teacher who believed all the necessary supplies were contained in the FOSS kits wrote,

I do all of the science kits. Units on Air, Weather, and Plants are the main things I did this year. Students are highly engaged and motivated while doing the science lessons. I had all that was needed for the lessons in the respective kits. This is one reason why I taught the units.

In an interview, a second grade teacher stated the benefits of having all materials as she stated, “I received 2 kits--Soils, Solids, and Liquids--all materials were provided and this helped me a whole lot. All of these lessons are completely hands-on and students enjoy learning science this way.”

Grade 4-5 teachers believed FOSS kits transformed the nature of teaching science. These teachers also reported the convenience of all materials being delivered to them and refurbished every year. They also commended the first-hand experience they had in doing the experiments form the kits during summer training. A fourth grade teacher wrote:

I was able to implement the units on electric circuits and motion and design. I had all the materials and equipment to do these two units in the kits. Moreover, these were the two units covered during the training and this made it easy in my class.

A fifth-grade teacher who considered the FOSS kits and the training useful wrote,

I did the unit on aquariums this year. Everything I needed was in the kit. I did this unit during the training with other teachers. This was group work in my class also. Since I did
the experiments during the training, I had a learning experience. I think this made me better prepared to do the unit in my class.

Similar comments relating to the usefulness of FOSS kits and training were given by teachers in Grades 4-5 during interviews. A majority of these teachers indicated implementing at least one of the FOSS kits during the present academic year. A fourth-grade teacher stated in an interview,

I was able to implement the unit on electricity this year. It was very convenient to have all the equipment for this unit. I did this unit during the summer training. Also, the teachers’ manual walked me through each experiment in this unit. I did this unit completely

Teachers received the instruction manuals to go with each FOSS kit. A majority of teachers across all grade levels considered these manuals useful and essential to do the science lessons. Teachers also commended the layout of the science teachers’ manual and that each lesson specifically stated how it met the science objectives for that grade level. Also, teachers reported the science experiments and instructions in the manual were parallel and easy to use. A second grade teacher who believed the science manual was user-friendly wrote, “Every detail for each lesson is spelled out clearly and it is so easy to follow. The manuals tell me what sheet needs to be copied for each lesson. These sheets have the appropriate questions related to the lesson.”

Teachers in Grades 4-5 were appreciative that the science manuals were aligned with the State standards. According to these teachers, only by doing the lessons from the FOSS kits they got all the science objectives covered. In an interview, a fifth grade teacher stated,

All units come with manuals with step-by-step guidelines and how each lesson in the kit aligns with state objectives. I teach one kit every year and have the main science objectives covered with just one kit. The science manuals walk me through the scientific method in doing experiments and I am getting better at it every year.
Other favorable comments on science manuals included the simple layout, easy to follow directions, separate manuals for each kit, and lessons aligned to State standards. A fifth grade teacher wrote,

The manual tells how much time the lesson is probably going to take. Due to this warning, I break lessons which take more time. Also, the manual is descriptive of each step, so I am able to plan when to stop to have easy continuity the next day. Some lessons require the experiment set up to stay untouched for 2-3 days and the manual states it. I do such lessons on a Friday morning. The manual has helped me plan the days and time to get the best use of the science lessons.

The last resource mentioned by the teachers was the *Global Observations and Learning to Benefit the Environment (GLOBE)* equipment. Two sets of GLOBE equipments pertaining to each grade level was sent to the schools and the grade level teachers had to share, thus each teacher did not have his/her own personal supply of GLOBE equipment.

A majority of K-3 teachers wrote that safety was their primary concern when using the Globe materials, while Grade 4-5 teachers wrote time, troubleshooting technology, and applicability in the classroom were their concerns. A kindergarten teacher who believed students’ safety as questionable doing GLOBE projects stated during the interview,

I did not use GLOBE this year. I need a lot of adult help coordinating the students and it is not possible for me to let the students dig the soil and also make sure all are safe. Moreover, when other science lessons cover the objectives safely, why [should I] do GLOBE?

Dissatisfaction with GLOBE projects was evident when a first grade teacher stated, “I did not do GLOBE projects. GLOBE is difficult with the age group I teach.” Another first grade teacher who believed she needed more training to implement GLOBE projects wrote, “I am not comfortable with the way GLOBE projects are set up. I do not use GLOBE. The training to use these GLOBE equipments is not comprehensive.”
Grade 4-5 teachers also had concerns about GLOBE projects. Their primary concerns were the problems of using the GLOBE materials, the GLOBE materials not always working appropriately, and the time consumed if they tried a GLOBE project in their classroom. A fifth grade teacher wrote, “I did not fully understand how to use the GLOBE materials during the training. I do not have the time to learn how to use it, master the ways of using it, and do with my students. So, no GLOBE.”

In an interview with fourth and fifth grade teachers, a fourth grade teacher reported,

I did GLOBE this year. I had to change the lessons to suit the needs of all the students. I will not do this in future. It was a challenge to complete the unit, and consumed a whole lot of my time. The technology provided was trouble shooting. It needs to be tweaked a lot to make it user friendly.

A majority of the Grade 4-5 teachers had consistent views about GLOBE like the K-3 teachers and believed it was a waste of 2 days. A fourth grade teacher wrote, “Yes, I did this during the training. The trainer was not confident and made many mistakes while showing how to use the equipment. I think this whole GLOBE thing can be avoided.” Another fifth grade teacher who considered GLOBE was cumbersome stated in an interview,

GLOBE is rough around the edges and no need to do it to cover the science concepts. Spending two days of science training on GLOBE can be avoided. Maybe they could train us more on time management techniques and how to accommodate more lessons.

Of the teaching resources, FOSS kits and science manuals had the most favorable comments and GLOBE projects had the least favorable comments. A majority of teachers across all grade levels considered the training time spent on GLOBE could be avoided.

Time. The final theme was time. Teachers across all grade levels indicated time was a primary factor in being unable to implement all of ASMTI science. In Grades 2-3, a majority of the teachers reported the units were picked up by the AMSTI personnel before all the lessons
were taught, and in Grades 3-5 a majority of the teachers reported the pressure of testing got in the way of teaching science, thus making it impossible to do all lessons in science kits.

Kindergarten and first grade teachers reported having sufficient time to do all the science lessons in both kits they received. However, second and third grade teachers had different views concerning time to do all the science lessons. A third-grade teacher wrote,

I am unable to complete all lessons in any one unit because they get picked up before I complete. Also, when I do such teaching, I need more time since the students come up with questions which require me to spend more time on some lessons.

Interviews with second and third grade teachers brought identical thoughts to the front. In an interview with second and third grade teachers, a third-grade teacher indicated,

I need more time to do all the science lessons. At present I pick a few lessons in one unit and not touch some lessons. The ideas provided are good. Initially it takes time to orient the students with inquiry-based learning and this takes time. The first few lessons take longer than other ones simply because this is a different way of teaching science. So, if I had more time, I could possibly implement all the lessons in the kits. Also, when we are getting close to finishing the unit, the kits get picked up, thus I have not been able to do any one kit completely.

Another third grade teacher who had difficulties completing all the units wrote, “We need to be taught how to condense these lessons so that they are less time consuming. Now, I follow the manual--it is well laid out and it also takes time to complete one lesson.”

Teachers in Grades 4-5 reported that, as the testing time approached all time was devoted to teaching reading and mathematics and thus science got put behind. During the allotted science time, other subjects were taught due to external pressures from the administration. These teachers also reported they were in a position to prepare students for the next level in reading and math, thus science was not taught consistently like other subjects.

While reporting the influence of time and interference of other subjects, a fourth-grade teacher stated in an interview,
Sometimes I have to stay longer than I planned in the topics and the school gets anxious. They want me to spend more time teaching math and cut short the time for teaching science. I do not get to do all the lessons. Sometimes the kits go back untouched.

A fourth grade teacher who had similar views on the influence of time wrote, “We all like to spend more time in science, but I am held responsible for showing results in math and reading. So, science gets neglected in the second term.”

A majority of fifth-grade teachers reported the pressure of testing took away teaching time for science. A fifth grade teacher who indicated external pressures prevented her from teaching science wrote, “The school wants to make sure all students meet the benchmarks in math and reading. Science is not a top priority, making AYP is the goal for my school every year.” Interviews with fifth grade teachers reflected other concerns related to time. A fifth grade teacher who believed he would able to do one unit per year stated his reasons in an interview:

AMSTI science is good, but time consuming. I do not have that kind of time for doing all lessons in science. The tests and EQT follow me like a shadow and we are unable to get the best of this initiative. I have been able to fit one unit comfortably this year within the available time.

Another fifth grade teacher mentioned it takes time and space to set up these lessons and they need space for other things in the class. He wrote, “The space gets occupied for a longer duration since the lessons in the kit take a long time to be completed.”

Thus, insufficient time has played different roles in various grade levels. However, teachers of all grade levels also wrote all the time devoted to teaching science improved conceptual understanding of science topics, student engagement, and a curiosity was aroused for the subject. They also considered the resources helped in implementing inquiry-based learning.
CHAPTER V
FINDINGS AND CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this study was to investigate elementary teachers’ perceptions regarding mathematics and science training and implementation of a state-mandated professional development program in Alabama and its impact on instructional strategies (AMSTI). The research questions were as follows:

1. Is there a difference in second-year K-5 teachers’ perceptions of AMSTI training, implementation, and practices in mathematics and science across grade levels?

2. What are the second-year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in mathematics?

3. What are second-year AMSTI trained K-5 teachers’ perceptions of their AMSTI training, implementation, and practices in science?

4. What are second-year AMSTI trained K-5 teachers’ perceptions of AMSTI mathematics?

5. What are second-year AMSTI trained K-5 teachers’ perceptions of AMSTI science?

Differences Between AMSTI Mathematics and Science

Research Question 1 sought to determine whether there were differences in second-year K-5 teachers’ perceptions of AMSTI training, implementation, and practices in mathematics and science. The findings indicated that significant differences in AMSTI science training,
implementation, and practices were evident. Significantly higher differences, meaning more positive perceptions, were seen in science for training in Grades 2, 3, and 5, and significantly higher differences, meaning more positive perceptions, were seen in science for implementation in Grades 3 and 5. For practices, there was an overall difference but not by grade level. Teachers’ perceptions of practices in science were more positive overall than their perceptions of practices in mathematics. Teachers in Grades 2, 3 and 5 had significantly more positive perceptions of the AMSTI science training than of the AMSTI mathematics training. Perhaps the differences in training can be attributed to the teachers being more confident in their abilities to use the science materials versus the mathematics materials. The teachers were trained intensively on two science modules each year. They were able to go through each module completely and do all the activities pertaining to each module. These activities were the ones they would be eventually presenting to their students. However, in mathematics the teachers were given five books (one from each of the five content areas), and a lesson from each book was selected to be completed by the teachers during the summer training. Therefore, the teachers never became familiar with all of the various mathematics lessons they would be asked to eventually present to their students. This could account for the more positive perceptions of the AMSTI science training than of the AMSTI mathematics training.

Desimone et al. (2002) indicated that professional development on specific instructional practices increased teachers’ implementation in the classroom. Lee, Deaktor, and Lambert (2008) emphasized the importance of content-focused training during professional development. Further, active engagement of teachers during professional development has been recommended by Darling-Hammond (2009) and Loucks-Horsley et al. (1998).
Research by Johnson (2006) and Suppovitz and Turner (2000) support the findings of this study. They found that while teachers need to learn new instructional methods, addressing topics in a fragmented manner does not serve the purpose. In addition, if information gained is only addressing bits and pieces of lessons, all teachers may not consider it useful and therefore not implement it (National Research Council, 2000). Knapp (2003) found similar results and reported that the episodic fragmented approach does not allow for rigorous, cumulative learning. Extrapolation is difficult when the teachers have not covered all the materials they need to present the lessons. However intensive training with all materials can increase the comfort level and confidence of teachers while they get ready to implement the training (Loucks-Horlsey, Hewson, Love, & Stiles, 1998).

In addition to the differences in training, teachers in Grades 3 and 5 had significantly more positive perceptions of AMSTI science implementation than of AMSTI mathematics implementation. Perhaps the differences occurred because in science the teachers were implementing exactly the same lessons they had learned and practiced during the science training. In mathematics, since all the lessons were not covered during the training, the teachers may not have been trained in the lessons they tried to implement in the classroom.

Science practices were higher overall in science than in mathematics. Perhaps because science modules were self-contained they may have been easier to implement than the mathematics lessons. In mathematics, the teachers had to find a way to add the AMSTI mathematics lessons to the existing curriculum they were required to teach. In science, the modules were a replacement for any science lessons the teachers may have been teaching. In addition, the results from the required science tests at the end of the year did not affect the schools’ Annual Yearly Progress (AYP) whereas the results from mathematics testing played a
significant role in affecting the schools’ AYP as well as teacher evaluations. Therefore, the teachers may have been more reluctant to stray from their school district’s mathematics curriculum in order to implement AMSTI mathematics.

Bright (2010) found similar results in her AMSTI study of elementary mathematics. She concluded that any professional development must be aligned with the existing curriculum in order for teachers to be willing to implement it. She stated that if it is not aligned, teachers are much less likely to put the professional development into practice in their classrooms.

Teachers’ Perceptions of AMSTI Mathematics

Research Questions 2 and 4 addressed the second-year AMSTI trained K–5 teachers’ perceptions of mathematics training, practices, and implementations. The results from the survey (which was addressing Research Question 2) indicated mostly positive perceptions in training, implementation, and practices in mathematics. Only one item on the survey indicated negative results, showing that the teachers did not spend less time on computation as a result of the AMSTI training. Even though AMSTI mathematics emphasized more problem solving and less computational work, the teachers did not appear to be incorporating this aspect into their classrooms.

The results of this study are similar to those of Kelly (2007) who conducted a study on the perceptions of elementary teachers who took part in AMSTI mathematics training in 2006. She found that about half of the teachers in her study did not spend less time on computation as a result of the AMSTI training. Porter (1989) determined that teachers spend from 70%–75% of their mathematics instructional time on computational skills. Thus, even with the AMSTI training it appears that the teachers are still very much concerned with computation and not as
much with problem solving. It is possible that teachers are not spending less time on computation because of the high stakes testing in their classrooms. They may be too concerned with the results on the computational portion of these tests to spend less time on computation and more time on problem solving. Teachers may find it easier to see more tangible results with the emphasis on computation than the emphasis on problem solving since a larger portion of the required tests are devoted to computation.

Research Question 4 resulted in three major themes. They were (a) communication, (b) teaching resources, and (c) time.

**Communication**

Teachers in all grades considered that improved student communication was one of the biggest benefits of AMSTI. Evidence of communication was seen through journal writing as well as through cooperative learning and math centers. Teachers stated that when they used journal writing, they were able to understand the ways students approached a problem since students explained their process though words or pictures. Further, teachers let students share their journals with the whole class and this also improved communication.

Communication also was increased as a result of cooperative learning as students worked in their groups and discussed the problems that were posed by the teacher with other group members. The lessons from *Investigations* required students to find different ways of solving problems. When students solved these problems in cooperative groups, students exchanged their views orally. These discussions helped the students look at the problem from different perspectives and improved problem solving skills as well as communication skills.
The other form of communication that was discussed by the teachers was math centers (in Grades K-3). In math centers there was communication among the students as they talked to each other about the math concepts on which they were working. Also, there was more communication about math concepts between the teacher and individual students as they worked through the center activities.

During the AMSTI mathematics training, the teachers had extensive professional development on the use of journal writing and oral discourse. It appears that they were able to implement these aspects of the training into their classrooms successfully. Communication in mathematics may have improved because teachers were now using more journal writing, cooperative learning groups, and math centers than they were before the training. Their confidence in using these strategies may have been bolstered by the extensive training in written and oral communication they had received during the summer workshops.

The findings in this study are similar to those found by Rivet and Krajcik (2004). They determined that professional development that focused on journal writing and was practiced by the teachers was one of the contributing factors that improved communication in the classroom. According to Marx et al. (2004), communication can be improved in the classroom when teachers have been exposed to different ways of promoting communication through professional development.

**Teaching Resources**

The mathematics teaching resources were another frequently mentioned aspect of the AMSTI training. The main resources were the mathematics manipulatives and the *Investigations* books. Teachers appreciated being given enough manipulatives for the entire class to use during
the *Investigations* lessons. They also were satisfied with the manipulative training and practice they had during the summer workshops. Although mathematics manipulatives and the training to use them were considered beneficial by teachers in all grade levels, they were used more by teachers in Grades K-3 than in Grades 4-5. The K-3 teachers believed that when they used mathematics manipulatives students were able to get more of a concrete understanding of abstract mathematics concepts and their attention span was longer. Teachers in Grades 4 and 5 were not as receptive to the manipulatives because they believed too much time was needed to use them effectively.

Research by Weiss (1994) supports the findings of this study on the use of manipulatives. The teachers in this study represent that national trend of manipulative use in lower grades and not much in the upper grades. Even though the upper-grade teachers had received the training on how to use the manipulatives, they still were reluctant to use them. It is possible that unlearning the traditional ways of teaching mathematics could have been a deterring factor for Grade 4 and 5 teachers not using manipulatives.

The results of this study that lower grade elementary teachers use manipulatives more often than upper grade elementary teachers also are supported by Howard et al. (1997). They found at the elementary grade levels, K-4 teachers using manipulative more often than their colleagues in Grades 5 and 6. Further, Malzhan (2002), while analyzing the national data, reported that the use of manipulatives was different for Grades K-2 students and Grades 3-5 students. For the K-2 group, it was found that more than 50% of the students used manipulatives in all or most of their mathematics classes and 15% of the other group used these tools often. More recently Florez and Wilkins (2010) conducted a study to investigate elementary teachers who had professional development that focused on use of manipulatives in teaching mathematics
to see if there is a relationship between grade level and frequency of the use of manipulatives in the elementary grades through a survey. They determined that kindergarten teachers used manipulatives most, followed by teachers in Grades 1 and 2, and the group that used manipulatives least was teachers in Grades 3-5 during mathematics instruction in their classrooms.

The other teaching resource was the *Investigations* manual. Teachers in Grades K-3 considered the *Investigations* manuals as beneficial resources. However, teachers in Grades 4-5 considered the *Investigations* manuals as complex and reported not using them as much. These teachers reported that the *Investigations* activities required a different set-up for each lesson, did not match the pacing guides given to teachers by the county school system, and were time consuming.

During the AMSTI summer training, random lessons were chosen from *Investigations* manuals and teachers were trained in those lessons. Such limited exposure to *Investigations* curriculum may not have helped the teachers to gain fluency in teaching it in their classrooms. Therefore, if the teachers chose to use *Investigations* lessons, then they had to spend additional time preparing for *Investigations* lessons with which they were not familiar. However, K-3 teachers were able to implement the *Investigations* lessons more frequently than teachers in Grades 4-5. Perhaps the K-3 teachers did not have to change as much of their previous teaching as did teachers in Grades 4-5. Typically, teachers in the lower grades use more student-centered, hands-on teaching of mathematics (which is emphasis of AMSTI) than upper-grade teachers.

Professional development programs should focus on opportunities for modeling, practicing, constructing, and reflecting on strategies (Suppovitz & Turner, 2000) rather than giving a preview of the new curriculum. Snow-Renner and Laurer (2005) stated that active
learning opportunities and reflection on teaching practices allow teachers to transform their teaching instead of layering new strategies over the old ones. Anderson (2002) reported that much of the difficulty in enacting any reform-based teaching is internal to the teacher, and includes teachers’ beliefs and values related to students, teaching, and purposes of education.

**Time**

Teachers in Grades K-2 reported they had enough time to implement most of AMSTI recommended methods of teaching mathematics. However, teachers in Grades 4 and 5 considered time was a barrier to implementing AMSTI mathematics. Their primary concern related to time was standardized testing. Teachers in Grades 4 and 5 stated they had to prepare their students for the Alabama Reading and Mathematics Test (ARMT) and the Stanford Achievement Test (SAT) and they were expected to cover a lot of objectives within a short period of time. Therefore, they did not have the time to devote to AMSTI lessons because they were concerned about teaching to the tests and the tests were not necessarily aligned with the AMSTI curriculum.

Possibly because the K-2 teachers did not have to prepare students for standardized testing, they did not feel any time pressure in implementing the AMSTI lessons in their classrooms. Moreover, they may not have had to make many adaptations to teach *Investigations* because they were probably already practicing student-centered ways of teaching mathematics such as collaborative learning and math centers.

Grade 4-5 teachers were unable to implement as much of AMSTI mathematics as lower-grade teachers, even though they were trained on how to implement these lessons from practicing classroom teachers at their respective grade level. The Grade 4-5 teachers may have
been reluctant to implement much of the AMSTI curriculum due to the pressure they felt from their school district on increasing mathematics test scores. In addition, the results of standardized testing played a vital role in the evaluations of the teachers so they undoubtedly wanted their students to perform well on those tests. They also may have felt too uncomfortable with the new AMSTI methods to let go of their “tried and true” ways of teaching mathematics.

The findings in this study are similar to those found by Volger and Burton (2010). They determined that testing influenced teaching practices in the classroom since teachers (88%) spent more than 2 months of mathematics teaching time towards preparing students for testing to improve scores in the tests. Further, research by Manouchehri and Goodman (1998) indicated having less time than needed for planning and instruction can deter the implementation of any program. Inadequacy of time can affect the successful implementation of a program.

Teachers’ Perceptions of AMSTI Science

Research Questions 3 and 5 addressed the second-year AMSTI trained K-5 teachers’ perceptions of science training, practices, and implementation. The results from the survey (which was addressing Research Question 3) indicated positive perceptions in training, practices, and implementation in science. The items on the survey showed teachers spent less time on memorization of science concepts, used more inquiry-based learning, and did more hands-on activities while teaching science.

Perhaps because the teachers had been trained on using a more student-centered hands-on approach to the teaching of science they were less concerned with the memorization of facts. They now had a method of teaching that was not just recitation of facts. They probably used more inquiry-based learning and did more hands-on activities because they had been trained in
these strategies and had received all the equipment necessary to implement these strategies. Their comfort level with teaching science in this manner had probably increased due to the intensive summer workshops.

The results of this study that specific and content focused professional development increased teachers’ implementation in classrooms is supported by Desimone et al. (2002). They determined that features such as active learning opportunities and content focused and sustained professional development increased the frequency of teachers’ implementation of inquiry-based science in their classrooms.

Similar findings were reported by Weiss and Pasley (2006). According to them, teachers participating in 40 or more hours of professional development in science and learning about inquiry-based based curriculum materials increased the amount of time spent on teaching inquiry-based science. In addition to spending more time in teaching inquiry-based science, it gave more opportunities for students to work with hands-on materials and learn science concepts by doing science.

Research Question 5 resulted in 3 major themes. They were (a) teaching strategies, (b) teaching resources, and (c) time.

**Teaching Strategies**

The two frequently mentioned strategies by teachers across all grade levels were inquiry-based teaching and science notebook writing. These strategies were different from what the teachers had been using in their classrooms in science instruction before the AMSTI training. Teachers considered that students’ engagement and conceptual understanding of science improved due to the implementation of these two strategies.
Inquiry-based learning required (a) hands-on learning, (b) group work, and (c) experiments done by students. Students had to confer with their group members in order to conduct these experiments. Due to the nature of inquiry-based lessons, teachers indicated that students were more involved during science lessons and their natural curiosity was aroused. Since most of the experiments were done in small groups, discussions were seen throughout the process, and cooperative learning was evident.

Because the teachers had received intensive training during summer to teach inquiry-based science and had opportunities to practice inquiry-based lessons while working in collaborative groups in the summer, they may have felt more confident to implement this in their own classrooms. Perhaps the intensive training they received allowed them to see the benefit of using inquiry-based teaching in science.

Similar results are found in a study conducted by Ackerson and Hanuscin (2007). They found that when teachers had intensive training in a professional development that focused on inquiry-based teaching in science most of the teachers showed positive views of the nature of science and used pedagogy such as inquiry-based teaching in their classrooms.

The other teaching strategy discussed by teachers across all grade levels was science notebook writing. Writing in science notebooks was considered useful because it improved organizational skills, and increased students’ accountability. Further, teachers considered using science notebooks as a necessary accompaniment to inquiry-based learning. Science notebooks improved student engagement and also documented the process students made as they did predictions, observations, and data collection, and then drew conclusions.

In lower-grades (K-2), science notebooks or class charts encouraged whole class discussions and student engagement. In upper-grades (3-5), science notebooks acted as a mirror
of students’ understanding of science concepts as students were expected to keep track of what they were doing in science classes. Thus, science notebooks served as a tool for ongoing performance assessment. In addition, students improved their skills in representing information using graphs, charts, and diagrams. Thus, when opportunities were provided and students were trained in using science notebooks, the teachers believed it helped in developing students’ analytical thinking and organizational skills.

The use of science notebooks as a part of science instruction is encouraged during the AMSTI training. Perhaps because the teachers had actually participated in notebook writing during the summer training, they felt more comfortable and confident in implementing this strategy in their classrooms. It is possible the teachers were fascinated by the novelty of the science notebooks and wanted to experiment with them.

The findings of this study, that professional development can help teachers implement the strategy of science notebooks, is supported by Aschbacher and Alonzo (2006). They found that the nature of guidance that teachers provided students for the notebook entries depended on the teachers’ knowledge about how to use science notebooks. The researchers concluded the teachers with professional development on implementing science notebooks considered this teaching strategy as effective and used it more than those teachers who did not have this type of professional development.

Teaching Resources

The science teaching resources were another frequently mentioned aspect of the AMSTI science training. The main teaching resources were the FOSS kits with the accompanying teachers’ manuals, and the GLOBE materials. The FOSS kits and the accompanying teachers’
manuals were used extensively by teachers of all grades but the GLOBE materials were not used by many teachers in any grade level.

Teachers stated that the training to use the FOSS kits and the accompanying teachers’ manuals was very useful. Moreover, teachers stated having all the supplies to implement their training was convenient. Teachers indicated the components of the FOSS kits played a vital role in implementing inquiry-based learning. Also, teachers indicated students were engaged doing the experiments and these kits, coupled with an inquiry-based approach to science, transformed the nature of learning science. Further, since the lessons in the FOSS kits were aligned with the state science standards, teachers found the transition to AMSTI science teaching was relatively easy.

Because the teachers did not have a formal program of science before the AMSTI training, it is possible that they were not using much hands-on science, if any at all. Therefore, with all the materials at their disposal and with the extensive training they received they probably were much more comfortable with teaching science and were willing to implement this inquiry-based program. Moreover, the well laid-out teachers’ manual may have added to comfort level of teachers in using this resource. In addition, the teachers were probably more willing to implement AMSTI science because it was aligned with the state science standards.

The results of this study are supported by Pistorius (2006) who conducted a study on middle school teachers’ perceptions of AMSTI science training. She found that some of the strengths of AMSTI science were the FOSS kits because they provided ready access to all materials needed for inquiry-based learning.

The next frequently mentioned resource was the GLOBE materials; however, the teachers did not have very favorable comments about this teaching resource. The difficulties faced by K-3
teachers were safety issues such as students doing GLOBE lessons outside the classroom and not having enough adult supervision. In addition, the concerns of Grade 4 and 5 teachers were the amount of time needed to do GLOBE projects and the lack of usefulness of GLOBE projects in addressing the state standards.

It is possible that access to additional adult supervision was not feasible and may have deterred the K-3 teachers from doing many GLOBE projects. If the teachers were concerned with the safety of the children while doing GLOBE lessons outside without any additional supervision, they may have decided to forego these lessons in favor of the FOSS lessons, which did not have those safety issues. Biggs and Tapp (1986) found similar results in their study and concluded that elementary teachers are concerned about students’ safety while teaching science outdoors. They also determined the reasons elementary teachers do not teach science outdoors included lack of administration support, fear of student management problems, lack of knowledge teaching in the outdoors, liability, and safety concerns.

The Grade 4 and 5 teachers indicated that they did not have enough time to include much science in their curriculum. Therefore, if they believed that the state science standards were not being addressed by the GLOBE lessons, they may have decided to spend whatever time they had to devote to science on the FOSS lessons, which aligned with the state science standards.

The results in this study about not using the GLOBE teaching resources are supported by Penuel et al. (2008). They found that although most teachers perceived the GLOBE program as consistent with their own goals of teaching science, nearly one-fifth of the teachers responded that GLOBE equipment was not “sufficiently consistent” with these goals. A majority of the teachers who participated in the program did not implement GLOBE with their students in their classrooms because they were not fluent in using the GLOBE equipments, the projects were time
consuming, and they were not necessary to meet all the science standards. According to Smith and Southerland (2007), the success rate of a professional development program depends on how well it is accepted and implemented by teachers in their classrooms.

Time

The final theme in science was the issue of time to fully implement AMSTI science. Teachers in kindergarten and first grade reported having sufficient time. However, difficulties with time were reported by teachers in Grades 2-5. Teachers in Grades 2-3 were unable to complete all the lessons in any one kit, as the kits were frequently picked up before they could teach the whole unit. Teachers in Grades 4-5 considered time was a barrier to teaching AMSTI science and therefore they were unable to implement much of it.

It is possible K-1 teachers did not face any problems with time because the science lessons may have been of shorter duration than in higher grades and therefore they had time to implement them. Also, since the K-1 teachers did not have the pressure of standardized testing they probably felt that they had more time to devote to teaching science than teachers in Grades 2-5.

In Grades 2-3, the teachers may have needed more time to establish the routines for working in groups doing inquiry-based learning with their students. Possibly there were too many lessons within each of the FOSS units for these teachers to be able to present.

Teachers in Grades 4-5 probably felt pressure to spend more time teaching reading and mathematics because those two content areas were stressed on the standardized tests they were required to give. Also, teachers were held accountable for the scores students earned, which influenced teacher evaluations. Therefore, when it came close to testing time, teachers probably
were forced to sacrifice the time used to teach science in order to better prepare their students in reading and mathematics.

One of the results of this study, that time is a barrier to implementing the training teachers received in professional development, is supported by Lester (2003). She found that in school, everyday tasks overwhelmed teachers and they did not have much time to implement the new ideas they learned in the professional development. The researcher concluded that professional development programs must consider accountability standards and the time required to do such teaching in a classroom while planning the program.

Another result of this study, that preparing for standardized testing is influencing teaching science, is supported by Harris, Curtis, and Burstein (2006). They found that the emphasis on standardized testing is impacting how the core subjects are being taught, with science and social studies being taught only when time permits. A survey by Jones et al. (1999) found that only 8% of instructional time was spent on science by most teachers.

Implications

1. AMSTI mathematics should be aligned with district pacing guides if teachers are to use it successfully in their classrooms. At present, teachers are caught between finding ways to implement both curricula when they have limited time in which to teach the existing non-AMSTI curriculum. The AMSTI mathematics training should include specific ways of showing how to infuse both curricula into the grade level school day.

2. The AMSTI trainers should show the teachers how each lesson in the Investigations manual relates to the state course of study.
3. More than 2 days of *GLOBE* training are required for it to be effective. The time devoted at present is not enough to enable teachers to feel comfortable doing the *GLOBE* activities.

4. Follow-up professional development sessions during the school year where teachers meet in grade-level groups should be offered to the AMSTI trained teachers. This would enable the teachers and trainers to see what problems are occurring with the implementation of AMSTI and help the AMSTI program revise and revamp the summer training.

Recommendations for Future Studies

This study investigated 89 K-5 elementary teachers’ perceptions of mathematics and science training, implementation, and practices on a state-mandated initiative (AMSTI). As a result of this study, the following recommendations are provided for further research.

1. This study should be carried out among a similar or expanded population, along with examination of student achievement scores, to see if AMSTI has made any impact in student performance.

2. This study should be conducted using technology as another component to identify teachers’ perceptions of the impact of technology due to AMSTI training. This study did not examine technology. Since it is associated with AMSTI, its role should be investigated.

3. A study should be conducted concerning the perceptions of elementary mathematics and science trainers about the training they receive and the strategies they use to train teachers. Such a study might give insights about mathematics and science trainers that could be used to address some of the concerns arising among teachers in this study.
4. Case studies should be developed of AMSTI trained teachers who use AMSTI methods of teaching math and science. These would be beneficial because we could have data from observations to see how they use these methods in their classrooms.
REFERENCES


APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL
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: Kuppal Malathy Naderanjan
Faculty Adviser: Dr. Cynthia Sunal
e-mail: cvmsul@bamaed.ua.edu

Second Investigator: Not applicable
Third Investigator: Not applicable

Department: Curriculum and Instruction
College: Education
University: University of Alabama
Address: 23051 Wilson Road
Loxley, Alabama 36551
Telephone: (205)-792-0101
FAX: 
E-mail: malathy@gmail.com

Title of Research Project: A study of Elementary Teachers' Perceptions of Mathematics and Science Training and Implementation on a State Mandated Initiative

Date Submitted: 08/12/10
Funding Source: Personal resources

Type of Proposal: [ ] New [ ] Revision [ ] Renewal [ ] Completed [ ] Exempt

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

II. NOTIFICATION OF IRB ACTION (to be completed by IRB):

Type of Review: Full board [ ] Expedited

IRB Action:
[ ] Rejected
[ ] Tabled Pending Revisions
[ ] Approved Pending Revisions
[ ] Approved-this proposal complies with University and federal regulations for the protection of human subjects.

Approval is effective until the following date: 8/12/14

Items approved:
- Research protocol (dated)
- Informed consent (dated)
- Recruitment materials (dated)
- Other (dated)

Approval signature: [Signature]
Date: 8/13/10
INFORMED CONSENT FORM

This is a pilot study conducted for a doctoral dissertation at the University of Alabama.
Name of the study: A comparative study on Elementary teachers' perceptions of Alabama, Math, Science, and Technology Initiative in mathematics and science training and its impact on teachers' instructional strategies. This pilot study is being done by Mr. Kuppal Nadarajan under the guidance of Dr. C.J. Daane for a doctoral dissertation.

The purpose of this study is to inquire elementary teachers' perceptions of Alabama, Math, Science, and Technology Initiative (AMSTI) training and its impact on instructional strategies. You are requested to participate in this study since you participated in the 2008 Summer AMSTI Institute and form a subset of the entire 2008 Summer trained AMSTI elementary teachers. You may not directly benefit from this study. However, this study is important since it can give insights of the perceptions of teachers about the two week training, its implementation, and its impact on their instructional strategies. There are approximately 115 participants in this pilot study throughout Baldwin County.

You will be asked to provide responses to questions related to (a) AMSTI mathematics, (b) AMSTI science and (b) demographic data. The required participation will be approximately 20 minutes for completing the surveys. This study will not cost you anything.

Although no risks, discomforts, or stresses are foreseen, answering some of the questions about perceptions and use of AMSTI may cause some discomfort. There are no direct benefits to you. However, the knowledge gained from this study could be beneficial to AMSTI personnel as they plan future training and also to others who plan professional development for teachers.

Your participation is voluntary and you may choose not to answer any question that causes discomfort. Refusal to participate will not involve any penalty or loss of benefits which you are otherwise entitled.

All the information you provide will be confidential and raw data will be destroyed upon completion of the pilot study.

If you have any questions, you may contact the following persons for further questions related to the study:
Kuppal Malathy Nadarajan (Mala) at (205)-792-0101 or mala.thy@gmail.com
Dr. C.J. Daane at (205)-348-1199 or cdaane@bamaed.ua.edu
You may also contact Ms. Tanta Myles, Research Compliance Officer for the University of Alabama at (205)-348-5152 or cmyles@ua.edu to inquire about research subjects' rights.

I give my consent to participate and will be given a copy of this consent form. I understand participation is voluntary. I understand I reserve the right of answering the questions which I choose to answer. I understand that I am completely free to withdraw my consent and to discontinue my participation at any time for any reason without penalty or loss of benefits for which I am entitled.

Participant's Signature: ____________________________
Grade Level: ____________________________________
School: _______________________________________

UNIVERSITY OF ALABAMA HBB
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EXPIRATION DATE: __10-8-10_
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<td>Team Building</td>
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APPENDIX D

AMSTI MATHEMATICS QUESTIONNAIRE
The purpose of this survey is to determine what you do in your mathematics classes and what your perceptions are about the mathematics component of the Alabama, Math, Science, and Technology Initiative (AMSTI). Your participation is voluntary and your responses will be kept confidential. This information is being collected for a doctoral dissertation at the University of Alabama and is not a part of the AMSTI program. Circle the responses that best matches your perceptions of AMSTI mathematics.

Strongly Disagree (SD); Disagree (D); Agree (A); Strongly Agree (SA).

| 1) Training at the 2009 Summer Institute prepared me for successful implementation of the AMSTI mathematics activities. | SD D A SA |
| 2) Participation in hands-on learning activities at the 2009 Summer Institute was important for successful implementation of the AMSTI mathematics activities. | SD D A SA |
| 3) I feel confident in my ability to manage the AMSTI mathematics manipulatives when implementing the activities. | SD D A SA |
| 4) As a result of AMSTI training, I spend more time guiding students in working cooperatively than before the training. | SD D A SA |
| 5) I feel comfortable asking the AMSTI math specialist to work with me. | SD D A SA |
| 6) As a result of AMSTI training, I spend more time developing students’ conceptual understanding than before the training. | SD D A SA |
| 7) The manipulatives provided by AMSTI are adequate for implementation of the AMSTI mathematics activities. | SD D A SA |
| 8) Collective participation by our school faculty provides a strong support system for implementation of the AMSTI mathematics activities. | SD D A SA |
| 9) The learning needs of students of different abilities can be met through AMSTI mathematics activities. | SD D A SA |
| 10) I was able to implement as much of the AMSTI mathematics curriculum as was asked of me at the 2009 Summer Institute. | SD D A SA |
| 11) My school’s administration is supportive of my implementation of AMSTI mathematics activities. | SD D A SA |
| 12) As a result of AMSTI training, I spend more time on problem solving than before the training. | SD D A SA |
| 13) As a result of AMSTI training, I spend less time on computation skills than before the training. | SD D A SA |
| 14) Training at the 2009 Summer Institute covered the content knowledge and pedagogy necessary for implementing the activities. | SD D A SA |
| 15) As a result of AMSTI training, I use a greater variety of assessment strategies in mathematics than before the training. | SD D A SA |
| 16) As a result of AMSTI training, I encourage my students to discuss their thinking to help them make sense of mathematics more often than before the training. | SD D A SA |
| 17) As a result of AMSTI training, I include more hands-on-activities than before the training. | SD D A SA |
23. On average, how many AMSTI mathematics activities do you use in your mathematics class per week? _______

24. I believe enough time is provided in the school’s schedule for mathematics to be taught effectively.

  ______  Yes  ______  No

25. Please estimate the number of minutes spent on the following in atypical daily mathematics lesson.

  _______  Investigations with manipulatives
  ________  Independent Practice of Computational Skills.
  _________  Other (Explain)
APPENDIX E

AMSTI SCIENCE QUESTIONNAIRE
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<td>1) Training at the 2009 Summer Institute prepared me for successful implementation of the AMSTI science activities.</td>
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<td>A</td>
<td>SA</td>
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<tr>
<td>2) Participation in hands-on learning activities at the 2009 Summer Institute was important for successful implementation of the AMSTI science activities.</td>
<td>SD</td>
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<tr>
<td>3) I feel confident in my ability to manage the AMSTI science kits when implementing the activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>4) As a result of AMSTI training, I spend more time guiding students in working cooperatively than before training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>5) I feel comfortable asking the AMSTI science specialist to work with me.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>6) As a result of AMSTI training, I spend more time developing students’ conceptual understanding than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>7) The materials provided by AMSTI are adequate for implementation of the AMSTI science activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>8) Collective participation provided by our school faculty provides a strong support for implementation of the AMSTI science activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>9) The learning needs of the students of different abilities can be met through AMSTI science activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>10) I was able to implement as much of the AMSTI science curriculum as was asked of me at the Summer 2008 Institute.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>11) My school’s administration is supportive of my implementation of AMSTI science activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>12) As a result of AMSTI training, I spend more time using inquiry (problem solving) approaches than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>13) As a result of AMSTI training, I spend less time on memorization than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>14) Training at the 2009 Summer Institute covered the content knowledge and pedagogy necessary for implementing the activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>15) As a result of AMSTI training, I use a greater variety of assessment strategies in science than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>16) As a result of AMSTI training, I encourage the students to discuss their thinking to help them make sense of science concepts more often than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>17) As a result of AMSTI training, I include more hands-on-activities before than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>18) As a result of AMSTI training, I use more effective questioning during science instruction than before the training.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>19) I believe that teaching with the AMSTI materials has been beneficial to my students’ understanding of science.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>20) Because of AMSTI training, I am more effective as a science teacher.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>21) My students show an increased interest and motivation to learn science when participating in AMSTI activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>22) Overall, I think AMSTI promotes an effective way to teach science.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>
23. On average, how many AMSTI Science activities do you use in your science class per week?

_____

24. I believe enough time is provided in the school’s schedule for science to be taught effectively.

______ Yes  ______ No

25. Please estimate the number of minutes spent on the following in a typical daily science lesson.

_________________ Inquiry based science activities
_________________ Writing in science journals
_________________ Other (Please explain)
APPENDIX F

OPEN-ENDED QUESTIONS
1. Describe the changes in your teaching of mathematics and science since you attended the AMSTI Summer Institute?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What are the greatest strengths of AMSTI mathematics/science?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. What are the greatest weaknesses of AMSTI mathematics/science?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. Describe the areas you consider in AMSTI professional development program which needs improvement.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. Discuss with examples how you use AMSTI mathematics and science in your classroom?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
6. Are you willing to participate in a focus group interview for approximately 30 minutes with 3 or more participants? Yes No

Demographic Information:

<table>
<thead>
<tr>
<th>Grade Level(s) you currently teach mathematics</th>
<th>K</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level(s) you currently teach science</td>
<td>K</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Number of minutes you teach mathematics/week</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of minutes you teach science/week</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of teaching experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Highest degree: Bachelor’s  Master’s  Educational Specialist  Doctorate
APPENDIX G

INTERVIEW PROTOCOL
Mathematics Questions:

1. What are your perceptions of the training you received in AMSTI mathematics?
   *Probe:*
   a. What was one activity or event that stood out? Explain.
   b. What might you have changed about the training you received in mathematics?

2. How has AMSTI impacted your teaching in mathematics?
   *Probe:*
   a. Does it have positive or negative impact on your teaching?
   b. Please explain the impact of AMSTI on your teaching with one or more examples?

3. What changes in your instructional strategies in mathematics have occurred as a result of your AMSTI training?
   *Probe:*
   a. What manipulatives from the Summer Institute do you use in teaching mathematics?
   b. How are you doing things differently in mathematics than you did before the AMSTI training?
   c. How do you feel about the changes you have made in your mathematics instruction as a result of AMSTI?

4. What do you consider as the strengths and weaknesses of the AMSTI mathematics training?
   *Probe:*
   a. Explain, giving examples, why you consider specific aspects as strengths?
   b. Explain, giving examples, why you consider specific aspects as weaknesses?

5. How well have you been able to implement AMSTI mathematics in your classroom?
   *Probe:*
   a. How often do you use *Investigations* in teaching mathematics?
   b. Using a scale of 1-10, with 1 being the least comfortable and 10 being the most comfortable, how would you rate your zone of comfort using the *Investigations* curriculum in teaching mathematics?
   c. In what ways do you incorporate writing in teaching mathematics?
   d. What impediments has AMSTI presented to your full implementation of AMSTI mathematics?
Science Questions

1. What are your perceptions of the training you received in AMSTI science?
   
   *Probe:*
   
   a. What was one activity or event that stood out? Explain.
   b. What might you have changed about the training in science?

2. How has AMSTI impacted your teaching in science?
   
   *Probe:*
   
   a. Does it have positive or negative impact on your teaching?
   b. Please explain the impact of AMSTI on your teaching with one or more examples?

3. What changes in your instructional strategies in science have occurred as a result of your AMSTI training?
   
   *Probe:*
   
   a. What science modules from the Summer Institute do you use in teaching science? Please tell me the topics for which you use them and how you use it (them)?
   b. What are the GLOBE projects you implemented in your classroom this year?
   c. How are you doing things differently in science than you did before the AMSTI training?
   d. How do you feel about the changes you have made in your science instruction as a result of AMSTI?

4. What do you consider as the strengths and weakness of the AMSTI science training?
   
   *Probe:*
   
   a. Explain, giving examples why you consider specific aspects as strengths?
   b. Explain, giving examples why you consider specific aspects as weaknesses?

5. How well have you been able to implement AMSTI science in your classroom?
   
   *Probe:*
   
   a. How often, and to what extent, do you use the Science modules (FOSS kits) in teaching science?
   b. Using a scale of 1-10, with 1 being the least comfortable and 10 being the most comfortable, how would you rate your zone of comfort using the Science Modules in teaching science?
   c. Using a scale of 1-10, with 1 being the least comfortable and 10 being the most comfortable, how would you rate your zone of comfort using GLOBE projects in teaching science?
   d. In what ways do you incorporate writing in teaching science?
   e. What impediments has AMSTI presented to your full implementation of AMSTI science?
General Question

How does AMSTI impact student achievement?

Probe:

Please explain what impacts you see; such as test scores in math/science, writing in math/science, conceptual understanding in math/science, use of vocabulary in math/science or any other.