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The Effect of the Alabama Mathematics, Science, and Technology Initiative (AMSTI) on Middle School Students' Scores in Mathematics and Science

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by

Toni Boyd Ramey

A Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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ABSTRACT

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The purpose of this study was to determine whether the application of the Alabama Mathematics, Science, and Technology Initiative (AMSTI) program in middle schools reduced the gaps found between students' CRT scores; specifically, did the gaps found in the CRT scores within the respective subgroups race, gender, SES, and special/regular education narrow? The subject areas considered by this study were mathematics and science. Student-level data were collected and examined for longitudinal changes over a three year period in which the AMSTI program was implemented at two participating public middle schools. The dependent variables used were mathematics and science CRT scores of 6th through 8th grade students. Three repeated measures MANCOVAs and one MANOVA were conducted in order to examine possible longitudinal changes in the mathematics and science scores of the student population as well as for changes in the gaps between the demographic groups of students within the subgroups. Significant decreases were found in the differences between the respective subgroups in the variables of SES and special education. The reductions were attributed to both mathematics and science. A significant reduction in the gap found between races was found, but could not be attributed to either mathematics or science. Gender was the only subgroup in which no significant change was found.

Additionally, a questionnaire was administered to teachers in four public middle schools in which AMSTI had been implemented. ANOVAs were used to examine the responses to determine how teacher training in AMSTI materials and techniques affected reported teacher attitude and frequency of usage of inquiry-based lessons. When the responses of teachers with less than one year of AMSTI training were compared to those teachers with more than one year of training, no significant change in teachers' reported attitudes toward inquiry lessons or the frequency of usage of inquiry lessons was found.

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CHAPTER I

INTRODUCTION

Background

This study examined the impact of the Alabama Mathematics, Science, and Technology Initiative (AMSTI) on the scores of middle school student in mathematics and science. The AMSTI program was a program created by educators, business people, and politicians to increase academic scores in the areas of mathematics and science for students in Alabama's public schools K-12 (AMSTI, 2008). Independent studies by the University of Alabama in Huntsville had found significant increases in these scores (AMSTI); however, at this date, no study had investigated the effect of AMSTI for individual subgroups for: race, gender, socio-economic status (SES), and special education ruling. With the pressure placed upon administrators and teachers by *No Child Left Behind* (NCLB) to ensure that all subgroups are academically successful, a need existed to study the effect of AMSTI on these student subgroups (Styron, Roberson, Schweinle, & Lee, 2005; U.S. Department of Education [USDE], 2004).

Girls, minorities, students from the lower SES, and special education students continue to score below the national average on standardized testing in mathematics and science (Grigg, Laulo, & Brockway, 2005; Jayaratne, Thomas, & Trautmann, 2003; Joyce, Weil, & Calhoun, 2000; Lee, Grigg, & Dion, 2007). The system of public education in the United States has failed to provide equal education for all students. A substantial and persistent achievement gap exists in the mathematics and science for each of these subgroups (Grigg et al., 2005; Lee et al., 2007). In a country whose population is historically diverse, it seems apparent that cultural, gender, or economic differences cannot be ignored in order to ensure educational equality.

According to *The Nation's Report Card* for 2005 and 2007, which uses data collected by the National Assessment of Educational Progress (NAEP), the scores of 8th grade students in mathematics and science have increased annually since 1990 with fewer students scoring in the lowest achievement group (Grigg et al., 2005; Lee et al., 2007). However, the good news that overall academic achievement is increasing only masks the underlying achievement patterns. As the scores have risen proportionally throughout the student population, only the gap between white and African American students has narrowed slightly (Grigg et al.; Lee et al.). Achievement gaps between the other races and whites, genders, SES, and special/regular education students overall have persisted.

Students eligible for free and reduced-price lunches, an indicator of poverty, still lag behind other students in mathematics and science achievement (Grigg et al., 2005; Lee et al., 2007). Despite increasing scores in mathematics and science at the national level, individual states across the United States have failed to address and correct the disparities between student achievement levels in the different SES groups (Lee & Wong, 2004). According to *The Nation's Report Card* in 2007, in mathematics, 8th grade students eligible for free or reduced-price lunches scored almost 10% lower than students ineligible. While in 2005 in science, the gap was more than double the one found in mathematics with eligible students scoring as much as 23% lower than those students who were ineligible for free and reduced-priced lunch (Grigg et al.; Lee et al.). The report also states that twice as many eligible students scored lower in both mathematics and science achievement as ineligible students.

The same trend is seen among races. In *The Nation's Report Card* in 2005 and 2007, 8th grade African American and Hispanic American students scored lower than white and Asian American students in mathematics and science (Grigg et al., 2005; Jayaratne et al., 2003; Joyce, Weil, & Calhoun, 2000; Lee et al., 2007). Additionally, in 2005, almost three times as many African American and Hispanic American students than white scored in the lowest achievement level in both subjects (Grigg et al.; Lee et al.).

Many minority students experience a double handicap as they comprise a large proportion of the lower economic bracket (Joyce, Weil, & Calhoun, 2000). The problem though is more complex than just being economically disadvantaged. Weinburgh (1994) stated that despite having more money, middle to upper-middle income African American students still performed at a lower level than white students. Low academic performance stemmed from peer pressure as well as socio-cultural influences (Weinburgh). Often, African American students were perceived as traitors to their race if they succeeded in school, which has been perceived as dominated by whites (Kahle & Damnjanovic, 1997).

Gender differences in NAEP scores are minimal, but do exist. Each assessment year, both boys and girls had shown improvement in 8th grade mathematics and science scores; but in both subjects girls consistently scored below boys (Grigg et al., 2005; Lee et al., 2007). Weinburgh's (1994) study found that in science girls have more negative attitudes than boys and stated that one reason for this difference may be that boys usually have more experiences with science at an earlier age than girls. This pattern may reflect the differences in societal expectations of boys and girls rather than abilities. Kahle and

Damnjanovich (1997) found similar results, stating that girls' attitudes become more negative in the high school years despite having similar academic scores to boys.

When the assessment is identical and the testing procedures and facilities are comparable, differences in mathematics and science scores most likely indicate individual differences in the students. Inquiry-based learning addresses these individual differences in students by allowing them to develop critical-thinking skills using their own natural talents, backgrounds, and perspectives (Llewellyn, 2002). Llewellyn stated that open-ended questioning and authentic assessment, an integral component of inquiry, allow for a wider variety of correct answers. The Alabama Mathematics, Science, and Technology Initiative (AMSTI), which is the focus of this study, is an inquiry-based program that allows students to have hands-on experiences with building equipment, modifying it, testing the design, and reporting the results (Alabama Mathematics, Science, and Technology Initiative [AMSTI], 2000).

Inquiry is a natural method of learning that individuals instinctively use beginning at birth (Llewellyn, 2002). Through inquiry, students follow a process of discovery, moving from concrete knowledge to abstract concepts, mastering subject content, and developing higher-order thinking skills (Joyce, Weil, & Calhoun, 2000; National Research Council [NRC], 2000a). In a process very similar to Dewey's learning theory; Llewellyn stated that through inquiry, students learn by actively engaging their environment, analyzing the results, and developing a conclusion. From their results, students construct knowledge and form theories, which they then test through interactions with their friends and in life experiences. The more effective the feedback is from successes and failures as well as from the students' peers, the stronger the students' knowledge (Llewellyn).

Inquiry uses authentic lessons and assessments that are based upon real life events and problems (Joyce, Weil, & Calhoun, 2000). According to Joyce et al., students can more closely associate with a familiar problem and the lesson is more easily and permanently retained as it becomes embedded in prior knowledge or schemas. Teaching inquiry-based lessons, though, requires more time than traditional teaching, but giving students this extra time to learn and internalize the concepts increases understanding and retention (NRC, 2000a). For students who are slower learners or lower achievers, extra time can be critical (NRC).

How a subject is taught can be as important as the subject itself (Cogan & Schmidt, 1999). Some suggest that inquiry is actually the most effective method of instruction for all students, regardless of gender, race, or ethnicity (American Association for the Advancement of Science [AAAS], 1993; NRC, 1996). Not only are students who have been taught with inquiry-based lessons more proficient on standardized tests, but inquiry is also seen as a necessary component of education to develop critical-thinking and problem-solving skills (Clark, 1999; Joyce, Weil, & Calhoun, 2000).

This study investigated a statewide inquiry-based program, AMSTI, which has been implemented in Alabama public schools at the K-8 levels since 2002. School participation in AMSTI is voluntary, but those who apply and are accepted receive supplies and training from the state without cost to their local school system. Through AMSTI, the Alabama State Department of Education trains the teachers in participating schools to implement inquiry-based lessons and provides the materials needed for the lessons in the areas of mathematics and science (AMSTI, 2008).

Research Questions

This study examined the effect of AMSTI on the mathematics and science scores of students in grades 6th – 8th by gender, race, special education, and SES. Criterion referenced test (CRT) scores of these subgroups for three consecutive years was compared using MANCOVAs. The first year included scores prior to AMSTI implementation; the second year included data after one semester of AMSTI; and the third year included data from a full year of AMSTI. Data were collected at the student level and the effect upon individual student scores was examined. Also, teachers' use of inquiry-based lessons as well as their beliefs in the efficacy of these lessons was studied using a survey instrument. This study sought to answer the following research questions:

1. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades?
2. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by gender in 6th, 7th, and 8th grades?
3. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students by socioeconomic status in 6th, 7th, and 8th grades?
4. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students

in special education versus regular education classification in 6th, 7th, and 8th grades?

5. Do teachers report a significant increase in the number of inquiry-based lessons used in the classroom after being AMSTI trained?

6. Do teachers report a positive increase in their perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained?

Purpose of Study

The purpose of this study was to determine the effect of AMSTI on students' scores in mathematics and science in the different subgroups: race, gender, SES, and special education. NAEP data indicated that students in some subgroups continue to have limited academic success. Even with national average test scores rising in mathematics, parity between the subgroups has not been attained.

No Child Left Behind (NCLB) requires schools to disaggregate data and identify the subgroups in need of improvement (USDE, 2004). Once at-risk subgroups have been identified, NCLB requires states to use research-based strategies to address identified weaknesses. States that refuse to comply or fail to meet federal standards of having all subgroups attain proficient, as determined by each state, risk losing federal funds. Additionally in Alabama, schools that do not meet adequate yearly progress, as determined by state policy, risk state intervention and possible restructuring by the Alabama State Department of Education.

With the emphasis on student achievement, it is essential for administrators of schools with large populations of minorities, high poverty levels, and/or special education students to implement programs that are most effective for their student population

(Styron et al, 2005). Research has indicated AMSTI to be a highly effective program for increasing mathematics and science scores; unfortunately, no data are available on AMSTI's effect on individual students' scores for different subgroups.

Hypotheses

This study was guided by the following hypotheses:

1. The implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades.
2. The use of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by gender in 6th, 7th, and 8th grades.
3. The use of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students by socioeconomic status in 6th, 7th, and 8th grades.
4. The use of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students with special education ruling compared to students in regular education in 6th, 7th, and 8th grades.
5. The use of the AMSTI program will significantly increase the number of inquiry-based lessons teachers report being used in the classroom after being AMSTI trained.

6. The use of the AMSTI program will significantly increase teachers' reported perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained.

Definitions

This study used the following definitions:

1. *Authentic* – can refer to lessons, activities, or assessments. Characteristics include tasks that reflect responsibilities or events that may be encountered in real life. These tasks usually allow students freedom to choose the method for solving the task and have more than one correct answer (Llewellyn, 2002).

2. *Critical-thinking skills* – are a group of abilities that enable a person to think independently and clearly. The group includes many characteristics such as: objectivity, analyzing, clarifying, identifying inconsistencies, persistence, and refusal to accept oversimplified explanations (North Central Regional Educational Laboratory [NCREL], n.d.a.).

3. *Higher-order thinking* – encompasses many skills including critical-thinking and problem-solving, which allow learners to evaluate information to find logical patterns, connect new ideas to known information; and recognize when information does not make sense (NCREL, n.d.c).

4. *Problem-solving skill* – allows learners to find or create solutions to quandaries. Learners use problem-solving skills to examine situations

analytically, identifying underling patterns of logic, and clarifying misunderstanding (NCREL, n.d.b).

5. *Special education student* – is a student who has undergone a battery of tests as determined by the federal government and has met the criteria established to be classified under Special Education. These students typically have Individualized Education Plans (IEP) that determine appropriate placement and educational services to help ensure academic success. This study does not include students who are classified under the gifted category of special education.

Delimitations

This study was delimited by the following:

1. Independent variables (IVs) were delimited to the subgroups: race, gender, SES, and special education.
2. Identification of subgroups was delimited to the information provided by school records.
3. Dependent variables (DV) were delimited to students' scores on criteria referenced tests (CRT) in mathematics and science.
4. Data analysis was delimited to running multiple analysis of covariances (MANCOVA) for each IV while controlling for the effects of the other IVs.
5. Data analyses for the AMSTI Teacher Questionnaire were delimited to paired *t*-tests and independent *t*-tests.

6. The participants were delimited to teachers who have had full AMSTI training for the grade level they are teaching
7. Student CRT mathematics and science scores were delimited to those who have CRT scores for three consecutive years for grades 6, 7, & 8 and who had AMSTI trained teachers in both the 7th and 8th grades in mathematics and/or science.
8. The timeframe of the study was delimited to the school years 2004 – 2005 through 2007 – 2008.
9. Measures of student achievement in mathematics and science were delimited to student CRT scores.
10. The measurement of teacher beliefs about the efficacy of AMSTI and use of inquiry-based learning was delimited to survey methodology using the AMSTI Teacher Questionnaire.

Assumptions

This study made the following assumptions:

1. This study assumed that data identifying race, gender, SES, and special education classification accurate and complete.
2. This study assumed that all CRT test data reported by the school system and schools accurate and complete.
3. An assumption was made that teachers involved in this study are implementing the AMSTI program as designed.

4. An assumption was made that participating schools presented accurate and complete information on which teachers attended AMSTI summer training sessions.

5. This study assumed that teachers filled out the questionnaire accurately and honestly.

Justification

With increased emphasis on accountability and the use of research-based methodologies, school leaders are seeking demonstrated methods for improving student achievement (Styron et al, 2005). Data analyses have shown unquestionable increases in student academic scores in mathematics and science with the implementation of the inquiry-based learning initiative, AMSTI. With NCLB forcing accountability for improving student achievement among subgroups, administrators need access to programs that target their specific school populations (Styron et al., 2005; USDE, 2004).

Fram, Miller-Cobb, and Van Horn (2007) conducted a study on learning environments. Their study indicated that learning environments, such as cooperative learning groups which is emphasized in inquiry learning and adequate, appropriate materials, have a positive effect on the learning of kindergarteners and 1st graders. These researchers further recommended subsequent research on learning conditions and the effect of different learning treatments on the academic progress of subgroups, specifically by race and socioeconomic status.

Xin Ma (2000) conducted a study of academic gaps by SES. Ma found academic gaps were reflected equally in the four core subject areas and suggested that most educational programs did not focus on these inequities, but instead focused on overall student achievement. Ma recommended that school administrators should search for programs that would reduce academic gaps by SES, but also acknowledged that few studies existed that focused on this area. By extension, a need exists for studies that focus on the effect of academic programs on different student subgroups to determine their strengths and weaknesses in order for administrators to be able to select appropriate programs for use in subgroup populations.

These studies provided justification for this study in that they recommended further research to examine the impact of interventions on the academic success of the subgroups included in this study. Chapter II provides further support for this study by reviewing the available literature to establish a foundation for inquiry as a viable learning theory as well as look at how inquiry was incorporated into the AMSTI program. The following literature review also discusses the potential of inquiry-based lessons for addressing the differences that are naturally found between the various subgroups. NAEP data were used to establish that substantial problems, in the form of low scores and the existence of serious and continuing gaps between the subgroups, are present in middle school mathematics and science in the U.S. and particularly in Alabama. Finally, this study took a comprehensive look at the AMSTI program's implementation. Chapter III discusses the methodology used by this study including the sample, instrumentation, procedures, and data analysis.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The American educational system leaves many middle school students unsuccessful academically in the areas of mathematics and science (Grigg et al., 2005; Lee et al., 2007). Education has long been believed to be the route to a successful life in the United States yet several subgroups were substantially behind the majority subgroups in recent NAEP assessments. Unfortunately, for many girls, minorities, students in the lower SES, and special education students, they are not succeeding in school and this lack of success may affect their ability to be successful as they enter into adult life.

This study centered upon an investigation of an inquiry-based program known as AMSTI. To gain a better perspective of AMSTI, this chapter begins with the review of relevant theorists whose work heavily influenced inquiry-based learning strategies followed by a discussion of the inquiry learning theory. Information will be provided describing what inquiry-based learning is and why students can learn with this learning method. Following discussion of theory, Chapter II looks at evidence of inequities in the U.S. public educational system and the weaknesses in mathematics and science curricula. Finally, Chapter II will describe the AMSTI program and its implementation. The theory section begins with John Dewey, followed by Jean Piaget and L.E. Vygotsky ending with inquiry-based learning.

Theory

John Dewey

Dewey (1916) asserted that education maintains a community's society, insuring that its children will be able to participate and enjoy the full benefits of membership. He felt that informal education, necessary for survival, is gained through experience with the surrounding environment and passed through the generations by children's imitation of adults; although, an undeveloped society can maintain its culture through informal education, Dewey believed that as the society became more developed, a gap would be created between the adults' culture and what children are able to absorb independently (Dewey).

To ensure children enjoy the advantages of their society, Dewey (1916) thought more formal education, consisting of the society's body of knowledge accumulated over time, was necessary. He was concerned, though, that formal education can be impersonal. According to Dewey, while informal education is used in every day life, knowledge learned through formal education may seem detached and unnecessary to the learner and asserted that learners need a balance of both informal and formal education (Dewey).

For Dewey, education's goal was to give children usable skills and knowledge in order to become productive adults in society (Dewey, 1916). In this respect, his beliefs contrasted with the contemporary opinions of his time about education. Rather than viewing the learning of a body of knowledge as an end in itself, Dewey maintained that learning is an active process that continues throughout a person's lifetime (Dewey, 1916; 1933/2004; 1938/1998; Tryphon & Vonèche, 1996). To him, education was not a collection of a narrow body of information; rather education should be rich and diverse, satisfying an intrinsic need of the learners. Therefore, education must be tied to the learner's interest as well as be actively engaging, becoming a blending of the student and the environment, opening the student's minds to possible problem-solving strategies (Dewey, 1916; Tryphon & Vonèche, 1996). Dewey asserted that the more actively involved learners are in their educational process, the more effective learning will be. In fact, Dewey criticized the separation of the process of mental learning and physical activity that sometimes occurs because he thought that learning cannot be developed without learners' active involvement (Dewey, 1916, 1939; Rodgers, 2002; Tryphon & Vonèche, 1996). He felt that passive education was merely theoretical and esoteric (Dewey, 1916, 1933/2004, 1938/1998, 1939).

According to Dewey (1916), controlling the learning environment is the only method of truly educating students (Dewey, 1916; Hansen, 2002). The learning environment, as described by Dewey, should include all objects, living and nonliving. The way these objects are presented or manipulated and the learners' interaction with them would determine what was learned, how well it was learned, and which affective qualities, such as attitudes and beliefs, that were developed (Dewey, 1916, 1939). Dewey thought that if the environment was not controlled and chance was allowed to determine the path of learning, a high possibility existed that learners would be poorly educated (Dewey, 1916, 1939; Hansen).

In *Democracy and Education: An Introduction to the Philosophy of Education*, Dewey (1916) criticized modern education. He felt that, traditionally, education had been separated into discrete subject areas such as reading, writing, and mathematics, but noted that learning emerged from all content areas. He believed that schools could not realistically teach content only, but instead should teach children to think. In fact, Dewey considered knowledge gained in learning to be secondary to a learner's development of the ability to think. As students learn to think, he said, they would develop methods of inquiry for observing their environment, making them more aware of characteristics and patterns that could be used in all subjects (Rogers, 2007).

Dewey (1916) asserted that effective thinking was evidenced by an increase in effective action. According to him, teaching that did not generate useful action by the student was counterproductive and provided obstacles to true learning. Additionally, Dewey stated that learning began with experiences created by an appropriate learning environment and if the teacher did not provide an authentic learning experience, students could not be expected to connect abstract lessons with effective actions. Dewey defined authentic experiences as those problems, which are related to the students and connected to their lives. He expanded this definition by stating that to be most effective, such experiences should be new or different from what students expect, yet still closely related to the students' prior knowledge so that it can be easily understood. Furthermore, the problem should be provocative and suggest additional steps. In the course of such authentic lessons, Dewey proposed that the students' learning evolved through solving the problem and that right answers were those that worked in reality, not necessarily the answers the teacher would have selected.

Dewey stated that, unfortunately, much of education consisted of artificial experiences resulting in non-authentic lessons and who students become bored and unmotivated. He decided that these experiences led to a poor education (Dewey, 1916; Rodgers, 2002). Furthermore, he stated that the traditional classroom format made active, authentic lessons difficult to produce because students were able to appear to be learning when in reality they were not (Dewey).

In order to solve problems, Dewey believed that students needed to reflect upon previous experiences and knowledge. He stated that learners identified solutions by analyzing data and organizing information into useful categories, which enabled easier access of information for future uses (Dewey, 1939). To Dewey, the culmination of thinking was reflection of the experience (Dewey, 1916, 1939, 1998).

Dewey regarded science not so much as a subject, but as an approach to knowledge because science is an applied subject that emphasizes critical-thinking skills rather than memorization (Dewey, 1916, 1939). Dewey asserted that the function of science was to teach students how to think by learning to develop concepts which could be transferred to another problem (Dewey, 1916). He stated that when correctly taught, science produced an attitude or philosophy towards life because learners develop a methodology to approach all types of problems (Dewey, 1916, 1939).

By developing the scientific approach to thinking in the educational process, Dewey felt that three thinking skill errors could be avoided (Dewey, 1939). First, subjective personal biases' interferences are decreased. Second, patterns of logic are analyzed rather than being viewed as disconnected pieces of data. Third, subjective approaches are reduced and replaced by objective methodologies (Dewey). Thinking, according to Dewey, is a process, which is best demonstrated through learners' actions.

Though students cannot be forced to think, Dewey asserted that educators could control what children learn by manipulating their environment (Dewey, 1916; Hansen, 2002). According to Dewey, since the ability to learn, think, and retain information defines what a person is, teachers fill an essential role because they deliberately manipulate students' environment in order to affect learning (Dewey, 1916; Hansen). He stated that authentic, activity based environments produce a set of desired learning responses while artificial, inactive lessons produce negative results by being too abstract or too unconnected to be of value to the learner (Dewey, 1916). Even as the educational process itself changes and enhances the life of those educated, Dewey also concluded that contact with teachers leaves a lasting effect on students (Dewey).

Jean Piaget

Like Dewey, Piaget (1972) also proposed that learning was a product of learners' interaction with their environment. He thought that this interaction of the learner with the environment, animate and inanimate, gives meaning to a concept. He felt that only by manipulating an object or event could learners develop an understanding of a concept (Piaget, 1971). Piaget referred to this action as "construction" where the students build mental models or schema from their experiences (Piaget, 1971). According to Llewellyn (2002), Piaget thought schema created an understanding of the experience. To Piaget (1971, 1972), knowledge consists of the learner acting upon a fact or event and changing it. He believed that the significance of knowledge was not that a learner possessed knowledge, but whether or not it could be transferred to another situation (Piaget, 1971). Once learners constructed a concept, Piaget said that the concept could be used to organize and make sense of new information; i.e. as learners perform new tasks, they demonstrate their knowledge (Piaget, 1971, 1972). Like Dewey, Piaget maintained that an educator's job was to select an appropriate environment for the learner to act upon so as to create the desired responses (Brainerd, 1978).

Piaget emphasized that learners should be actively engaged in their own discovery of ideas because self-discovery allows diverse learners to act differently on the same object and alter it in a variety of ways (Brainerd, 1978; Piaget, 1975, 1977). According to Piaget, learning could have greater quality and quantity if learners actively discover or construct concepts themselves because learning entails not just reproducing a physical model, but also recreating a new perception of the model (Brainerd; Campbell, 2006; Piaget, 1975, 1977). He believed that learning is about changing objects or understanding how they change, both of which is derived only from interacting with the object. Piaget explained that as learners act upon the objects, knowledge is obtained from the way the objects change (Campbell; Piaget, 1977).

Knowledge categories. Piaget categorized knowledge into two categories: physical and logicomathematical (Piaget, 1955). According to him, physical knowledge represents information gained from the learner's environment such as observations of color and shape while logicomathemetical knowledge is the perception that learners gain from internally establishing connections between concepts, such as a round shape being able to move in a variety of ways (Piaget, 1971). Piaget stated learning was the combination of both the physical empirical knowledge and perception.

Theory of cognitive development. As Piaget believed learning develops over time, so he believed that intelligence develops over time and constantly remakes itself through modifications in structure and organization (Piaget, 1968). Consequently, he developed a theory of cognitive development, which included three basic concepts: cognitive structure, cognitive function, and cognitive content (Brainerd, 1978). He proposed that these three components function cooperatively and fluidly to produce intelligence.

According to Brainerd (1978), Piaget referred to the physical, neurological form where information is stored as cognitive structures and maintained that such structures are related to the age or maturation level of the learner. Piaget, originally, was a naturalist and believed learning and intelligence were determined by the growth of the body and as the body matured so did the brain; therefore, as learners developed and were exposed to new information, the maturing cognitive structures in their brains changed (Brainerd).

A principle cognitive structure that was central to Piaget's theory of cognitive development is the one he called schema (Brainerd, 1978; Piaget, 1955). According to Piaget (1955), schema are cognitive structures that allow learners to sort their knowledge into meaningful categories. He explained that schema are the results of learners' active attempts to make sense of the world around them and are created and modified as the learners interact with their environment (Brainerd; Piaget). Piaget proposed that learners select schema that best fit a problem and assimilate or absorb the new information into the structure (Brainerd). Furthermore, he also stated that schema could be complex structures containing multiple and varied interrelated cognitive contents.

Once created, Piaget suggested that schemas are utilized subconsciously as information flows into the brain. If the new information does not automatically fit a schema, learners adjust their schema to accommodate the new input (Brainerd, 1978). Piaget thought that schema which successfully manage new information are retained; those that do not are deleted (Brainerd). The more that schemas are used, Piaget continued, the more generalized they become making them useful with more types of information and the more differentiated they become from other schema (Brainerd;

Piaget, 1955). He also thought that schemas begin simple and with use, become more complicated, more tightly interwoven, and more cohesive (Piaget, 1975).

The second concept of Piaget's theory of cognitive development was cognitive functions (Brainerd, 1978). He considered cognitive functions as the goal of intelligence with two of the most important cognitive functions being organization and adaption (Brainerd). According to Piaget, organization allows learners to categorize information into a meaningful order so it can be stored in cognitive structures such as schemas. Adaptations, he continued, explain how a learning experience affects the student (Brainerd; Piaget, 1955). He divided his concept of adaption into two parts: accommodation and assimilation (Brainerd; Piaget). He stated that learners assimilate or modify new knowledge to fit into pre-existing cognitive structures within their intelligences and the more mature and advanced learners' cognitive structures are, the more likely the knowledge will fit. If knowledge cannot be made to fit existing cognitive structures, Piaget said that learners accommodate or alter their own cognitive structures in order to make sense of the new information (Brainerd; Piaget).

Piaget proposed that learning is a continual process of students assimilating and accommodating new information. He called the balance between assimilation and accommodation equilibrium or equilibration. Conversely, disequilibrium occurs, according to Piaget, when learners encounter a situation that cannot be readily assimilated (Campbell, 2006). When disequilibrium occurs, he stated, learners are forced to accommodate the new information in order to re-establish equilibrium. The more an experience differs from the accepted model, the greater the disequilibrium that occurs and, therefore, the greater the change needed in the schema to accommodate the new information; however, if necessary, learners can construct original, more stable schema (Brainerd, 1978; Piaget, 1975).

Piaget's third basic concept, cognitive content, is the only concept that is directly evident (Brainerd, 1978). Cognitive content is simply the information that is stored in a learner's brain which, according to Piaget, is displayed through the learner's observable activities (Brainerd).

Stages of cognitive development. Piaget is perhaps best known for his theories of the four stages of cognitive development: sensori-motor stage, pre-operational stage, concrete-operational stage, and formal-operational stage (Piaget, 1972). According to Piaget, at the sensori-motor level, cognitive structures are absent and infants are unable to distinguish between themselves and things around them (Brainerd, 1978; Piaget). Basically, he stated that both the concepts of self and non-self are the same and children cannot develop understanding of permanent objects until they can distinguish between themselves and external objects. Piaget felt children relate to and act on their surroundings based completely upon themselves (Piaget).

In the preoperational stage, occurring at about 2 to 7 years of age, Piaget said young children learn to differentiate between self and non-self (Piaget, 1972). During these years, he believed children's cognitive structures develop that reflect relationships between concrete objects and actions they observe (Brainerd, 1978; Piaget). Overall, Piaget considered that learners in this stage operate only on the concrete level of action, without reflective thought (Piaget).

In the operational stage, at about 7 to 11 years of age, Piaget stated that children are able to use their understanding of concrete objects and their relationships and begin to problem-solve (Brainerd, 1978; Piaget, 1972). Additionally, learners at this stage are also able to perform reversible transformations where internalized concepts learned from a problem are changed and used to act upon another problem (Piaget). Piaget observed that near the end of this stage, learners should begin to deduce causality (Piaget).

Piaget referred to the fourth and final stage of cognitive development as formal operations, which begins during middle school, at about 11 years of age, and lasts throughout the learner's life time (Brainerd, 1978). At the beginning of this stage, Piaget thought children begin to lose their need for concrete concepts and objects and can reason in abstract terms (Piaget, 1972). At this point, according to Brainerd, Piaget thought the learner begins to be capable of problem-solving and critical-thinking using abstract concepts (Brainerd). Additionally, he proposed that learners in this stage are able to create and reason hypotheses (Piaget, 1972).

Like Dewey, Piaget's theories led him to conclude that teachers should provide an environment where learners can develop intellectually by actively discovering and/or constructing concepts. He acknowledged that such lessons would require more effort and creativity from teachers than more traditional lessons where information is passively presented to students (Piaget, 1975). According to Brainerd (1978), Piaget believed many teachers err when they provide a contrived or artificial scenario that requires learners to arrive at a single desired answer. Rather, he contended that teachers should encourage learners to solve authentic problems and submit answers that they determine are correct. Piaget asserted that teachers should facilitate learners, enabling them to arrive at a logical answer rather than leading students through questioning towards a single desired answer (Brainerd).

Piaget considered lessons to be more effective if learners are interested in the problem, noting as Dewey did that activity alone does not imply interest and participation in an active lesson does not necessarily mean students are learning (Piaget, 1975). Piaget stated that learners must be involved in the lesson and actively mentally processing information; when constructing a concept, learners are recreating concepts through assimilation and accommodation, not just mimicking an action (Piaget).

According to Piaget, children should mature, transforming from their own egocentric beliefs and viewpoints as young children to awareness of the diverse beliefs of others (Brainerd, 1978). To facilitate this goal, he suggested that children could be placed in peer groups and allowed to discuss their concepts. Brainerd explained that Piaget viewed peer tutoring as an asset to learning since children sometimes can learn from their peers what they could not learn from their teacher (Brainerd).

Les Vygotsky

Agreeing with both Dewey and Piaget, Vygotsky (1978) proposed that learners must be actively engaged with their environment; but while Piaget proposed that the child was the center of learning, Vygotsky believed social interaction and culture were the initiators of learning (Tryphon & Vonèche, 1996). Piaget believed learning began inside the child and externalized as the child matured, but Vygotsky contended that the child initially learned socially through culture and subsequently, internalized knowledge (Tryphon & Vonèche; Vygotsky, 1978). According to Vygotsky, students learn through active manipulation and interaction of their environment with learners first identifying external descriptions of objects and situations and then moving to internal descriptions or abstract concepts (Vygotsky, 1978). He further believed that learners' responses change as a result of their interaction with their environment, demonstrating learning (Vygotsky 1978, 2004).

According to Vygotsky (1978), small children first define and interact with their world within their society's cultural context. Children then would construct their own understanding (Galloway, 2001). Vygotsky strongly maintained that learners have their own internal cognitive structures that require social contacts to become defined and functional. Furthermore, like Dewey and Piaget, he contended interaction with the environment generates new knowledge and understanding individually for each child. Gradually according to Vygotsky, children would learn to identify situations and problem-solve; eventually, as learners mature, abstract ideas would be construed without conscious action. Ideas, he stated, could then be applied in other situations.

Vygotsky (1978) developed stages of cognitive development which were founded upon learners' developmental levels as evidenced by what learners are able to do independently (Vygotsky, 1987a, 1987b). Vygotsky's stages are not as clearly and rigidly delineated as Piaget's theories of the four stages of cognitive development. Instead, he described a more gradual maturation of learners' cognitive growth. He also developed a learning theory that delineated a plan for identifying the level of knowledge students had as well as the level at which they were capable of learning, theorizing that children are able to learn beyond their actual capabilities. (Vygotsky, 1978, 2004).

Zone of proximal development. Vygotsky identified the zone of proximal development (ZPD) as the difference between where learners are in their independent cognitive development and where their learning development can be with intervention from facilitators (Vygotsky, 1978). He defined independent cognitive development as the knowledge and skills learners possess independently while the learning process is what students can learn with support (Vygotsky, 1978, 1987b). Knowing the level of a student's ZPD is more useful for planning instruction than actual developmental levels, he contended since identifying the ZPD enables educators to determine what would be reasonable to expect the student to learn (Vygotsky, 1987a, 1987b). He asserted that if learners are able to perform a skill level with facilitation, then learners can be expected to achieve this same level independently (Vygotsky, 1987b). Moreover, once a student's independent cognitive development level is determined, lessons should be conducted on a more advanced level that, with facilitation, learners can attain. After the learner achieves the more advanced level and is comfortable with the required skill level, the instructional support should be withdrawn, allowing the learner to become independent at that level (Vygotsky, 1978). Vygotsky maintained that such social facilitation and encouragement could push learners to advance their own cognitive development.

MKOs. Vygotsky recognized the benefit learners derived from their facilitators whom he called More Knowledgeable Others (MKOs). He stated that social contacts play a very important role in learning development and that students can learn more with a MKO than independently (Galloway, 2001). According to Tudge (1990), studies have indicated that children whose learning is facilitated by adults are more successful at learning. Both teachers and students, Vygotsky stated, can function as MKOs. Moreover, he believed that students develop different perspectives depending upon who their MKOs are; students with peer tutoring develop different perspectives than those with adult MKOs or even with students in different cooperative learning groups (Tudge). Vygotsky contended that the social contacts learners make initially begin the learning process and shape its direction as the learners mature and interact with their environment (Tryphon & Vonèche, 1996).

Inquiry-Based Learning

Dewey, Piaget, and Vygotsky all asserted that learners must construct their personal knowledge by interacting with the lesson (Dewey, 1916, 1939; Llewellyn, 2002; Piaget, 1972; Vygotsky, 1978). These beliefs are now called constructivism. As evidenced by Dewey, Piaget, and Vygotsky, constructivists believe active participation by learners is a major source of learning (Dewey, 1916; Llewellyn, 2002; Piaget, 1972; Vygotsky, 1978).

Inquiry is the combination of the preceding theories and is considered an extension of constructivism (Llewellyn, 2002). According to constructivists, inquiry is a major source of learning because it stresses students' reflection upon the lessons (Llewellyn). Even though most inquiry is hands-on, which is constructivism, according to Llewellyn, it also is a process that actively engages the mind as well. In inquiry learning, students are required to reflect upon why something happens, not to just physically manipulate objects. Using inquiry, students learn by making observations, interacting with their environment, and analyzing the results; as they perform these tasks, the students become investigators and scientists (Dewey, 1916; Joyce, Weil, & Calhoun, 2000; Llewellyn; Piaget, 1972; Vygotsky, 1978). From their results, they construct knowledge and form theories which are then tested through interactions with their peers and through experiencing life's successes and failures. The more positive and effective the feedback students receive from their experiences, the stronger their knowledge (Llewellyn).

Inquiry is a process that is a natural method of learning, which individuals instinctively use from birth (Llewellyn, 2002). Take the examples of toddlers placing things in their mouths to discover the concrete qualities of objects or the three year olds who are always asking, "Why?" As children ask questions about new things, they rely on their original understandings and scaffold new knowledge onto old, which allows a more secure internalization (Llewellyn). During inquiry, students essentially follow this same process of discovery becoming aware of what they know and how to incorporate new knowledge (NRC, 2000a).

The process of inquiry. Inquiry is not one procedure, but rather a way of teaching and learning (Gooding & Metz, 2008). Classrooms that include inquiry generally include: independent student learning, active manipulation of materials by students, student use of higher order thinking skills, student driven lessons, peer collaboration, active discussions, lessons that contradict commonly held beliefs, and sufficient time allowed for students to contemplate the lesson and elaborate and consolidate what has been learned (Layman et al., 1996). Educators typically choose lessons based upon their knowledge of their specific student population and their students' experience with the subject content and then combine authentic problems with unique and varied facilitation methods (Gooding & Metz).

Inquiry-based lessons are learner-orientated rather than teacher-orientated (Harris & Burke, 2008). In a typical inquiry lesson, teachers may begin lessons with a discrepant event that is different than the students' common conceptions causing them to ask, "Why?" (Llewellyn, 2002). The result is a "teachable moment," in which students are open to new ideas. Teachers then help students explore their prior knowledge, aiding them in using correct terminology (Harris & Burke; Layman, 1996). Students might design as well as conduct experiments to test their ideas. As students discuss and work towards solving the problem, teachers act as facilitators during the lesson, asking clarifying questions (Harris & Burke; Layman et al.; Llewellyn). Teachers do not direct students to the correct procedure or answer, but they allow students to learn through logical thinking even if mistakes are made (Layman). Afterwards, students analyze data and reach a conclusion. Constructing a hypothesis, testing it, and then reaching a conclusion all consists of applying knowledge to a new situation which, in turn, creates better understanding (Marzano, 2001).

The last step, which distinguishes inquiry from constructivism, is that students reflect on their work, deciding what was right and wrong with their processes, determining what other questions could have been asked, and further developing their critical-thinking skills (Llewellyn, 2002). Upon completion of the lesson, students communicate their findings either through presentations or written reports (Gooding & Metz, 2008; Harris & Burke, 2008; Layman et al., 1996; Llewellyn). As students explain, clarify, and support their ideas with evidence, they repeatedly use the same information, reinforcing the lesson into their memories (Byrnes, 2001; Gooding & Metz; Jensen, 1998).

Inquiry requires the use of advanced questioning skills, where teachers ask leading questions, draw information out of students, and at times are at odds with students, requiring them to actively defend their conclusions with evidence and logic (Gooding & Metz, 2008; Harris & Burke, 2008). As teachers present opposing views, students learn to reflect on other opinions, learning that there may be more than one right answer (Gooding & Metz; Joyce, Weil, & Calhoun, 2000; Llewellyn, 2002). As students create, revise, review, and communicate their results, information is processed in a variety of ways resulting in an increase in students' higher-order thinking skills (Byrnes, 2001; Jensen, 1998; Joyce, Weil, & Calhoun; Gooding & Metz; NRC, 2000a).

Inquiry's effect on learning. Research suggests that inquiry may be the most effective teaching method for students, regardless of gender, race, SES, or special education classification (AAAS, 1993; NRC, 1996, 2000b). Numerous articles, education experts, and institutions, such as National Science Education Standards (NSES) (NRC, 1996), Project 2061, CAWSMET (Commission on the Advancement of Women and Minorities in Science), and NSTA (National Science Teachers Association), call for lessons which emphasize inquiry as a necessary component for the development of higher-order thinking skills (Clark, 1999). Inquiry is two-fold in purpose in that it teaches high-order thinking skills in addition to content by having students actively participate in a lesson (Llewellyn, 2002). Students who use inquiry are more likely to master content concepts, develop higher-order thinking skills, and gain a positive attitude towards science (Clark; Joyce, Weil, & Calhoun, 2000). The results can include better understanding of processes, increased problem-solving skills, and higher standardized test scores (Joyce, Weil, & Calhoun).

Inquiry-based lessons are lengthy, giving students more time than traditional teaching techniques to learn the concepts and internalize them, thereby increasing understanding and retention (NRC, 2000a; Willis, 2007). For students who are slower learners or lower achievers, such as children classified as special education, this extra time is critical (NRC). Instead of placing lower achievers in classes which may feature inquiry-based lessons, many schools opt to place lower achieving students in less demanding classes that emphasize standardized testing preparation (Clark, 1999). Unfortunately, most learning associated with standardized test preparation consists of memorization and basic content knowledge rather than critical-thinking skills (National Science Foundation [NSF], 1992).

Many inquiry-based lessons incorporate cooperative group learning. Peer as well as class discussions allow students to make sense of the lesson and what they have learned. Robert Marzano et al. determined, through a process called meta-analysis, that cooperative learning is a highly successful form of student learning (2001).Weinburgh found that cooperative learning groups are especially helpful for girls, who studies show do better with cooperative learning groups. Also, lower achievers benefit because of the support they receive from working with stronger learners (Weinburgh, 1994).

When implemented correctly, inquiry can address most students' needs. Although, teachers choose lesson content, the students are allowed to select the manner in which they explore and address the lesson (Llewellyn, 2002). This student involvement permits students to choose directions reflecting their own cultural backgrounds, and therefore, incorporating a variety of life styles into the lesson (Baker & Leary, 2003). When students are personally involved in decision-making, their brains process the information faster and retain the information better (Willis, 2007). Allowing a certain degree of student autonomy is important, especially for girls and minorities whose subcultures have often been marginalized by the mainstream culture (Baker & Leary; Weinburgh, 1994). Inquiry-based lessons enable students to include their own personal cultures in the lesson, which has a positive impact on female and minority academic success (Clark, 1999; Shin & McGee, 2002).

Another characteristic of inquiry-based lessons which has a positive impact on female and minority academic success is the use of hands-on authentic experiences (Shin & McGee, 2002; Clark, 1999). Authentic lessons can interest and motivate students, creating stronger images and memories resulting in greater retention of knowledge (Willis, 2007). The more personal and authentic the lesson is, the stronger the stimulus is; the stronger the stimulus generated, the greater the impact upon learning (Calvin & Ojemann, 1980; Joyce, Weil, & Calhoun; Willis, 2007). Stronger stimuli can also produce stronger emotions that keep students more focused for longer periods of time (Willis).

Weaknesses of inquiry. A problem often attributed to inquiry-based lessons is ambiguity surrounding the specific content to be taught during the lesson (NRC, 1996). Inquiry is process-oriented emphasizing conceptual content and scientific processing skills while many curricula are content-specific and objective-based (Lucks, 1999). Some opponents of inquiry state that students, in general, are more successful when content goals are clearly stated as in content-specific curriculum (Lindsay, 2002). Other critics state that inquiry's emphasis on student individuality and open-ended conclusions make it a poor choice for preparation for standardized tests, where there is only one right answer (Llewellyn, 2002). Unfortunately, use of standardized testing is widespread in education and often a major part of assessments required by NCLB (USDE, 2004).

Another criticism of inquiry is the time required to teach a concept. The open-ended method of inquiry requires increased time for preparation and assessments. With the increasing number of objectives emphasized by national and state standards, teachers may feel that they do not have time available for inquiry-based lessons (Llewellyn, 2002; Lucks, 1999; Valverde & Schmidt, 2006). Lewellyn stated that some educators think that teaching the broad subject concepts and the higher-order thinking skills found in inquiry may not raise their scores; but, in fact, may lower them due to less time being available to be spent directly on test material. Other methods of teaching, such as direct instruction, use the available instructional time more efficiently than inquiry (Lucks). Furthermore, some studies indicate students were more successful academically with traditional direct teaching (Lindsay, 2002).

A critical component to successfully implementing any new program or methodology is thorough, vigorous professional development; yet many teachers have limited exposure to inquiry-based instruction and few have been trained in it (Hassard, 2000). A comprehensive professional development program should not only target current classroom teachers, but also consider the needs of new teachers who are constantly being hired. The financial investment in such professional development is justified because true reform requires time and long-term financial commitments (USDE, 1996). Because the effectiveness of any model of teaching depends upon how well the teacher is prepared both in content and methodology, schools committed to implementing inquiry in the classroom will have to dedicate the necessary funds and time to maintain training for the long term (Joyce, Weil, & Calhoun, 2000).

Case Studies

Inquiry recently has gained popularity in the education field. Because different types of inquiry exist, inquiry studies are very diverse. Five case studies were selected for inclusion in this review of literature to illustrate the potential effectiveness of inquiry-based instruction. The first, by Shin and McGee (2002), studied the effect of a physics software program on 9th grade girls' achievement. The second study featured inquiry-based learning in an elementary science class, but the methodology is not content specific and could be used in any subject area (Pegg, 2006). The third case study focused on how understanding and competency is accomplished in middle school classes (Gresalfi, Martin, Hand, & Greeno, 2008). The fourth case study examined an authentic lesson in a middle school and its implications in its extension outside the classroom (Van't Hooft, 2005). The final case study examined the differing needs of gifted elementary students and how inquiry lessons can address those requirements (McAllister & Plourde, 2008). The final example, the Bayer/NSF Awards, has been included even though it is a project rather than a study because it demonstrated the success of inquiry-based education with gender and racial subgroups (Baker & Mack, 1998; Lightell, 2001).

Shin and McGee Study

Namsoo Shin and Steven McGee (2002) studied the effect of inquiry on gender differences in physics for 9th grade students. The lesson plan resource material used by Shin and McGee (2002) was *Astronomy Village*, a computer-based simulation of a series of events in space. A virtual tutor directed students through the simulations and into several authentic situations that the students must solve. Students were placed in teams and worked through a series of exercises. Teams kept logbooks and presented their findings at the end of the project. In addition to logbooks and presentations, pre- and post- tests were administered, which were graded using rubrics to assess both conceptual understanding and problem-solving skills.

When the data were analyzed, the study found that the inquiry activities were successful for both genders although girls' scores made the most improvement. Girls initially scored lower in the concepts covered by this program than boys, but showed the most improvement and in the post-test scored higher than the boys for both subject concepts and problem-solving. The software *Astronomy Village* demonstrated an increase in understanding and problem-solving skills with inquiry lessons and that inquiry can assist in reaching parity between the subgroups in gender.

Claims-Evidence Inquiry

Jerine Pegg's (2006) dissertation research at the Oregon State University investigated the effect of claims-evidence inquiry lessons on middle school students in science. Claims-evidence inquiry is a type of inquiry that is developed upon students generating questions based on known subject concepts. In the study, students selected their questions and developed a procedure to study their question. By investigating their questions, students learned problem-solving skills as well as the subject concepts. The focus of this specific study was to examine how the inquiry learning method affected student learning and what those changes were.

The quantity of content knowledge students possessed prior to the lesson was found to be a major influence on the success of the lesson (Pegg, 2006). Additionally, when teachers presented the concepts prior to be the lesson, learning increased. Pegg determined that the more inquiry skills students possessed before the lesson, the more successful students were. Based on her findings, Pegg concluded that teachers should work to develop good inquiry skills in students since the method students chose to answer the questions greatly impacted their explanations and their learning. Students who had poor inquiry skills tended to select procedures that produced inconclusive data which resulted in minimal learning. Pegg asserted that evidence supported the use of inquiry in the classroom, but how teachers presented the lesson heavily influenced the success of the students.

Constructing Competence

Researchers Gresalfi, Martin, Hand, and Greeno (2008) theorized that competence of a concept was not only the outward display of actions of learners but, instead includes when understanding is internalized by an individual. This understanding, they continued is unique to each person and is gained by exercising personal responsibility and interacting with a problem within its environment.

Researchers contended that a person may possess the skills to be competent in one environment yet be incompetent in another setting. To test this belief, the study examined the effect of an inquiry-based program called Algebra Project. The Algebra Project used a process of steps that required students to be actively participating in sharing information, modeling knowledge, problem-solving, and creating representations of learning. The researchers used three mathematics classes as the environments: one each of 6th, 7th, and 8th grade levels, but focused primarily on the 6th and 8th grade classes. The 6th grade teacher was trained in the Algebra Project while the 8th grade teacher was not.

Researchers found that the 8th grade students were determined to be competent in the specified task only if they arrived at the correct answer by solving the problem using the correct method. The 6th grade students were evaluated in light of their activities and though individuals may have used different methods to answer a problem, they may still have gotten the answer correct. Researchers concluded that learning is a process rather than a single answer and classrooms should be organized so that student learning is maximized by providing multiple opportunities to learn and demonstrate learning.

Ohio Schools

Van't Hooft (2005) studied the effect of involving 7th grade students at a middle school in an inquiry-based learning program that emphasized problem-solving and real-world application to events outside the classroom. The middle school that participated in this study had a solar panel installed as part of a project for the U.S. Department of Energy called Ohio Energy Project (OEP). Students were to collect data throughout the school year and report it to the U.S. Department of Energy. The goal of this project was to interest students in alternative forms of energy and to provide a real-world context for learning. Students engaged in hands-on data collection and problem-solving, technology-oriented webquests, and more traditional learning such as concept maps and notes.

Though approximately half the students preferred more traditional forms of classwork, Van't Hooft found an increase in student perception towards learning science. He also found that students felt that the more concrete, hands-on lessons were more effective in creating understanding. The researcher, furthermore, found that knowledge learned through inquiry-based lessons was more likely to be applied outside the classroom.

Gifted Students

Researchers, McAllister and Plourde (2008), believed that gifted mathematics students have become collateral damage in the high stakes testing game fueled by NCLB. Gifted students, they contended, are not challenged by curricula designed to meet low to average achievers' needs resulting in boredom and disinterest in learning. Researchers stated that gifted students learn differently and need different types of lessons which allow them to challenge their abilities. To meet the needs of the gifted students at an elementary school and improve attitudes towards learning, students at a participating school were asked to take part in an inquiry-based lesson where they plan a day at Disney World. Plans included an activity schedule, money management, determinations of how many people the trains at Disney World could carry per day, etc. The activities were inquiry-based where the students applied higher-order thinking skills to real-world problems. Results indicated that students' attitude towards learning improved with students actively engaged in higher-order mathematics and problem-solving.

Bayer/NSF Award

Each year, the Bayer/NSF Award, sponsored by Bayer Corporation, National Science Foundation (NSF), Christopher Columbus Fellowship Foundation, and Discovery Magazine, challenges middle school students to solve community problems (Baker & Mack, 1998). Students form four member teams, identify a problem in their community, and using science and technology, solve the problem. Past entries include: creating a safety harness for a neighborhood playground rather than dismantling the swings, studying turning compost into alternative energy, and conducting a study to build straw housing in order to solve a housing shortage for the Crow Nation (Baker & Mack; Lightell, 2001). The entire process each team completes is the ultimate exercise in a type of inquiry that is called open inquiry, where the students choose the problem, write their research question, design a procedure, conduct their experiment, and conclude their findings. Even though this competition attracts students who are already interested in science and are probably very successful in it, it is interesting to note that, in 2002, 30% of entrants were minorities and 60% were girls (Baker & Mack; Lightell).

Major Events in Educational Reform

Since Thomas Jefferson first proposed a universal system of education, immeasurable changes have been made to public education in the United States (March & Willis, 2003). Almost as soon as this educational system was established, Benjamin Franklin initiated changes in the traditional classical curricula by adding practical vocational training (Marsh & Willis). In 1893, the National Education Association (NEA) founded the Committee of Ten, composed mainly of educators, which recommended a curriculum for secondary schools consisting of four different tracks, all of which were to prepare students for college although two were considered more advanced (Marsh & Willis; NEA, 1895). The recommended curricula emphasized subject content rather than a classical theme with a slight move toward practical subjects such as the sciences (Marsh & Willis). The Committee of Ten's curricula allowed no leeway concerning the subjects to be taught although some flexibility remained within the courses themselves (Marsh & Willis, NEA).

In the twentieth century, largely due to the influence of Dewey and other influential theorists, educational practices in the United States became more student-orientated (Marsh & Willis, 2003). The NEA once again created a committee, the Commission on Reorganization of Secondary Education. The committee wrote the *Cardinal Principles of Secondary Education* (Marsh & Willis). The report declared that education should help build a student into a responsible and productive citizen and that any subject matter that did so was acceptable, returning some flexibility to the curriculum

(Marsh & Willis). For the first time, emphasis was placed on the development of the student and recognition was made that students are individuals and may need different curricula (Marsh & Willis).

In 1930, the Progressive Education Association (PEA) created the Commission on the Relation of School and College (Marsh & Willis, 2003). This committee developed the Eight Year Study which was designed to evaluate different curricula's value in preparing students for success in college as well as life (Aiken, 1942; March & Willis). Thirty schools were selected to develop their own individual community-based curricula and their students were followed through high school and college (Aiken, 1942; March & Willis). The study found that students who graduated from the thirty experimental schools experienced a slight advantage in college over those students graduating from schools with traditional curricula (Aiken; March & Willis). Additionally, the students from the selected schools experienced a marked success in life. The Eight Year Study provided evidence that individual-orientated curricula were slightly more successful at preparing students for college and even more successful in preparing students for life in general than traditional curricula (Aiken; March & Willis). This study was considered a landmark study, but unfortunately did not have much impact at the time due to the start of WWII (March & Willis).

Post WWII, the race to launch the first satellite into space began and when the USSR became the first nation to accomplish this feat by launching Sputnik in 1957, the leaders in United States perceived this accomplishment as a threat to national security (Marsh & Willis, 2003).This resulted in an emphasis being placed specifically on mathematics and science when President Kennedy charged the American educational system to produce graduates who were experts in these fields and capable of meeting the challenge of winning the space race (Marsh & Willis). The Sputnik incident provided the federal government an opportunity to become involved in public education which previously had been the province of the state governments and an emphasis became for schools to have a common curriculum (Marsh & Willis).

In 1965, the federal Elementary and Secondary Education Act (ESEA) was passed to ensure equal educational opportunities for every child (Alexander & Alexander, 2005). ESEA involved the federal government to an extent previously unknown in public education. ESEA ignored the Eight Year Study's findings concerning the potential of differing curricula and, instead, selected successful research-based programs and implemented them throughout the nationwide (Marsh & Willis, 2003). No consideration was given to the fact that programs proven to be successful in local areas may not be successful if widely dispersed without adaptation to local individualities. ESEA has been reauthorized since its creation and eventually, the federal government's focus shifted from dictating specific programs to establishing comprehensive ideas at the federal level which allowed schools to select and implement specific learning programs suited to their particular needs (Marsh & Willis). Due to the federal government's involvement through ESEA, school accountability for student achievement became the catchphrase of politicians during the 1970s through the dawn of the 21st century (Marsh & Willis).

In 1983, *A Nation at Risk* was published by the National Commission on Excellence in Education (Marsh & Willis, 2003; USDE, 1983). Even though this report had serious inaccuracies, it served as a wake up call (Marsh & Willis). This document stated that the United States' educational system was mediocre and that the average citizen in 1983 was not as well educated as those of 25 to 35 years earlier (Marsh & Willis; USDE). The report's recommendations though were weak, in light of the harsh judgment it passed on the educational system, and primarily concerned the type and number of classes in which students should enroll, the length of the school year, the amount of time spent in class per day, and the amount of homework given to students (Marsh & Willis; USDE).

A subsequent report, *America 2000,* was published, under the presidency of George H. W. Bush in 1991. *America 2000* established new educational goals that were, unfortunately, very broad and idealistic including such goals that by 2000 all children would enter school ready to learn, high schools would have a 90% graduation rate, all American adults would be literate, and all schools would be drug-free (Marsh & Willis; USDE, 1994). The next president, Bill Clinton, signed into law the *Goals 2000: Educate America Act*, which expanded and put into law President George H. W. Bush's *America 2000* goals (Jennings, 1997; USDE).

Reform continued under the next presidency when President George W. Bush reauthorized ESEA with the signing of the *No Child Left Behind* (NCLB) (McKim, 2007; USDE, 2004). As the name suggests, NCLB is based on the idea that all children can learn and that all children should be successful in school (USDE). For states receiving federal money through NCLB, this Act requires school accountability for the success of students in each subgroup including race, gender, SES, and special education classification with a minimum enrollment of 40 students in a subgroup per school (USDE). School accountability is determined by data such as standardized test scores, graduation rates, and attendance rates (USDE). NCLB, like its predecessor ESEA, also requires these schools to use research-based programs (USDE).

On February 24, 2009, President Barack Obama recommitted citizens of the United States to education, stating that it is no longer acceptable that so many of the nation's children fail in school. He remarked that three-fourths of new jobs require more education than a high school diploma yet in 2008, the U.S. had the largest high school drop-out rate of any industrialized nation. President Obama challenged the country, parents and children, to improve the educational system by stating "we know the countries that out-teach us today will out-compete us tomorrow" (Obama, 2009).

Achievement Gaps in Mathematics and Science Education

To further investigate achievement gaps among students in select subgroups in the United States' public educational system at the middle school level for mathematics and science, this review of literature includes an examination of data found in *The Nation's Report Card* which is produced by the National Assessment of Educational Progress (Grigg et al., 2005; Lee et al., 2007).

The National Assessment of Educational Progress (NAEP) is a unique and valuable source of information concerning the health of public education in the United States. NAEP is an ongoing national longitudinal study being conducted by the Institute of Education Sciences (IES), a branch of the U.S. Department of Education (U.S. Department of Education Institute of Education Sciences [IES], 2008). Standards were set by the steering committee, the National Assessment Governing Board (NAGB), which is a political taskforce with board members who were either elected officials or who were appointed by the United States Secretary of Education (Grigg et al., 2005; Lee et al., 2007; USDE, 2009). Members have included governors, classroom teachers, measurements specialists, principals, superintendents, and private citizens whose task was to determine the assessment standards and measurement tools used by NAEP (Lee et al.; USDE, 2002).

NAEP assessments were designed to measure subject content, critical-thinking skills, and problem-solving skills in grades four, eight, and twelve (Grigg et al., 2005). National longitudinal assessment began in the 1970's and state assessments began in 1990 (USDE, 2008). Assessments are administered approximately every four years in several subject areas, including mathematics and science. Assessment results are published periodically in *The Nation's Report Card* which is featured prominently in the news media (USDE).

NAEP data were analyzed across race, gender, socio-economic status (SES), special education, as well as other variables (Grigg et al., 2005; Lee et al., 2007). Each variable is subdivided by student scores and categorized into four achievement levels: advanced, proficient, basic, and below basic (Grigg et al.; Lee et al.). These levels were determined by the NAGB who identified the type and quantity of knowledge students should know and the skills these students should be able to use for each grade level and subject assessed (Grigg et al.; Lee et al.; USDE, 2002). Based on this information, cut scores which define each achievement level were established. The designation "basic" indicates partial mastery of the assessed skills. "Proficient" indicates competency with content and the ability to apply that subject knowledge to real life problems. The last two groups are "advanced," which includes students who perform above the expected level of knowledge and skills, and "below basic," which includes students who do not have the partial mastery of the subject necessary to perform basic functions (Grigg et al.).

Mathematics

The Nation's Report Card: Mathematics 2007 reported that, since 1990, NAEP has found statistically significant increases in the overall eighth grade students' scores in mathematics except between the 2005 and 2007 assessments (Lee et al., 2007). As scores have increased, fewer students were found in the below basic category. These improvements were seen uniformly throughout the student population (Lee et al.). When the following data from *The Nation's Report Card: Mathematics 2007* were examined, disturbing patterns were discovered within the subgroups of race, gender, SES, and special education (Lee et al.).

Race. As seen in Table 1, Asian American and white students have consistently scored significantly higher than other races; and in 2007, Asian American students scored 6 points higher than whites in mathematics. In fact, Asian American students scored higher than whites and for this reason were not considered an at-risk minority in this present study. But, since 1996, even though the gap between the scores of white and African American students decreased 10 points from 41 points to 31, a substantial gap still remained. A similar gap was found between the scores of whites and Hispanic American students, which decreased only 4 points from 30 points to 26. No data were available for Native Americans in 1996, but the gap in 2000 was 25 points which, instead of decreasing, rose 2 points to 27 in 2007.

Table 1

Mathematics Scores by Race

	Year				
	1996	2000	2003	2005	2007
White	281	284	288	289	291
Asian American	NA[a]	288	291	295	297
African American	240	244	252	255	260
Hispanic American	251	253	259	262	265
Native American	NA[a]	259	263	264	264

Note. Total points possible =500.
[a] NA indicates no scores were available.

When the percentage of students in the achievement levels were compared in Table 2, the disparity was striking. Almost twice as many white students scored in the advanced achievement level as African American, Hispanic American, and Native American students combined; and ironically, almost twice as many Asian American students scored in the advanced achievement level as whites. When the below basic achievement levels were examined, Lee et al. (2007) found that 53% of African American, 45% of Hispanic American, and 47% of Native American students scored in the below basic achievement level when compared to only 18% of white students. According to this information, almost half of all African American, Hispanic American, and Native American students in 2007 did not possess the basic mathematics knowledge and skills that the NAGB determined were necessary to be productive in American society.

Table 2

Mathematics Percentages by Race and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
White	18	82	42	9
Asian American	17	83	50	17
African American	53	47	11	1
Hispanic American	45	55	15	2
Native American	47	53	16	2

Note. Total points possible =500.

Gender. Data for male and female subgroups did not show the same gap in mathematics scores or achievement levels as the racial subgroups. Since 1996 the scores of both genders made statistically significant gains with boys and girls each gaining 11 points (Table 3). The only assessment year that did not demonstrate significant gains was 2007. Each assessment year, the girls' scores paralleled the boys' scores, but continued to remain 1 to 2 points below. Almost a third of all students, both genders in 2007, scored in the below basic achievement level with only 6% of girls and 8% of boys scoring in the advanced achievement level (Table 4).

Table 3

Mathematics Scores by Gender

	Year				
	1996	2000	2003	2005	2007
Boys	271	274	278	280	282
Girls	269	272	277	278	280

Note. Total points possible =500.

Table 4

Mathematics Percentages by Gender and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
Boys	28	72	34	8
Girls	29	71	30	6

Note. Total points possible =500.

Socioeconomic status. NAEP uses family income to determine students' socio-economic status (SES) as expressed in eligibility for free or reduced-priced lunch in the federal food program (Lee et al., 2007). Families of students qualify for free lunches earn an income of 130% or less of the federally determined poverty level or less. Families of students who qualify for reduced-priced lunches earn an income of 130% to 185% of the poverty level (Lee et al.). "Eligible" students were those who qualified for either free or reduced-price lunch while "ineligible" students qualified for neither category.

Both eligible and ineligible students' scores in mathematics increased overall since 1996; eligible students by 15 points and ineligible by 14, but the achievement gap existing between these two groups remained in 2007 (Table 5). In 1996, ineligible students scored 27 points higher than those students who were eligible; in 2007, the gap had been reduced by only 1 point to 26. When achievement levels were examined (Table 6), a pattern similar to the one seen in the racial subgroups was found. In 2007, 45% of students eligible for free or reduced-lunch did not have basic mathematic skills as compared to 19% of those students who were ineligible and five times as many ineligible students scored in the advanced achievement level as eligible.

Table 5

Mathematics Scores by SES

	Year				
	1996	2000	2003	2005	2007
Ineligible	277	283	287	288	291
Eligible	250	253	259	262	265

Note. Total points possible =500.

Table 6

Mathematics Percentages by SES and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
Ineligible	19	81	42	10
Eligible	45	55	15	2

Note. Total points possible =500.

Special education. NAEP data for students with disabilities were inclusive of all disabilities. Many of these students had individualized education plans (IEP), which determine if students need accommodations such as small group settings. For the 2005 data, NAEP classified special education students in two categories: those tested without accommodations and those tested with accommodations. For the purpose of this review, only the set of mathematics scores without accommodations was examined in order to maintain consistency since the prior years had no accommodations provided for any student.

From 1996 to 2007, scores for both regular and special education students increased. Regular education students' scores rose 12 points while scores for special education students rose 15 points (Table 7). However, in 1996 special education students on average scored 42 points below regular education students. Unfortunately, that gap decreased only slightly to represent a 39 point gap in 2007. An even more dramatic difference is found in achievement levels for 2007. As seen in Table 8, two-thirds of special education students scored in the below basic level compared to one-fourth of regular education students. Unfortunately, less than 1% of students in either group scored in the advanced achievement level.

Table 7

Mathematics Scores by Special/Regular Education Classification

	Year				
	1996	2000	2003	2005	2007
Special education	231	230	242	245	246
Regular education	273	276	282	283	285

Note. Total points possible =500.

Table 8

Mathematics Percentages by Special/Regular Education Classification and Achievement Levels

	2007		
	Below basic	Below basic	Below basic
Special education	66	34	8
Regular education	25	75	34

Note. Total points possible =500.

Science

In 2005, *The Nation's Report Card: Science* indicated that 8th grade science scores had no statistical significant changes between the 1990 and 2005 assessments (Grigg et al., 2005). Unfortunately, science scores have remained relatively unchanged since 1996 with the national average 8th grade science score remaining 149 out of a possible 300 points for the last three assessments in 1996, 2000, and 2005. But, as with the mathematics NAEP data, when the data were examined from *The Nation's Report Card: Science*, underlying patterns were revealed (Grigg et al.).

Race. Disparities in science scores between the racial groups, unfortunately, have been consistent (Table 9). The white to African American gap decreased by only 2 points from 38 points in 1996 compared to 36 in 2005 while the white to Hispanic American gap remained consistent at 32 points. The scores of Native American students did not increase during this time, but rather declined sharply from 148 in 1996 to 128 in 2005, nearly tripling the white to Native American gap from 11 points to 32 points.

Table 9

Science Scores by Race

	Year		
	1996	2000	2005
White	159	161	160
Asian American	151	153	156
African American	121	121	124
Hispanic American	128	127	129
Native American	148	147	128

Note. Total points possible =300.
[a] NA indicates no scores were available.

The scores of Asian American students were slightly lower than those of white students with a gap of 8 points in 1996 which decreased to 4 points in 2005. As with the NAEP mathematics scores, the science scores of Asian American students were very similar to white students, who scored highest each assessment year. In general, two problems were found: overall science scores did not improve and the gaps between white students and the other races (excluding Asian Americans) were stagnant except for those of Native American students which plummeted.

Table10

Science Percentages by Race and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
White	26	74	39	<1
Asian American	34	66	36	<1
African American	72	28	7	<1
Hispanic American	65	35	10	<1
Native American	NA[a]	NA[a]	NA[a]	NA[a]

Note. Note. Total points possible =300.
[a] NA indicates no scores were available.

Gender. NAEP science scores for both male and female students showed no statistically significant changes between 1996 and 2005; neither was there a noteworthy gap found between the genders (Table 11). The achievement gap increased from only 1 point to 2 points in 1996 and to 3 points in 2005 with boys outscoring girls.

Table 11

Science Scores by Gender

	Year		
	1996	2000	2005
Boys	150	153	150
Girls	148	146	147

Note. Total points possible =300.

Table 12

Science Percentages by Gender and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
Boys	39	61	32	<1
Girls	43	57	26	<1

Note. Total points possible =300.

Socio-economic status. Overall, science scores increased from 1996 to 2005 for both ineligible and eligible students; however, improvement was minimal in view of the fact that ineligible student scores rose only 3 points while eligible student scores rose only 1 point (Table 13). In 1996, a substantial gap existed between the two subgroups; students who were ineligible for free or reduced-priced lunch scored on average 28 points higher than those who were eligible. This gap increased 30 points in 2005. In addition, when the achievement levels were examined in 2005, almost two-thirds of eligible students were found to have scored in the below basic achievement level as compared to one-third of ineligible students while less than 1% of all students scored in the advanced achievement level (Table 14).

Table 13

Science Scores by SES

	Year		
	1996	2000	2005
Ineligible	157	159	160
Eligible	129	127	130

Note. Total points possible =300.

Table 14

Science Percentages by SES and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
Ineligible	29	71	38	<1
Eligible	63	37	12	<1

Note. Total points possible =300.

Special education. Science scores of students with disabilities (special education students) increased 7 points from 1996 to 2005 compared to students without disabilities (regular education) whose scores increased by 1 point (Table 15). Unfortunately, special education students, who were 38 points behind regular education students in 1996, still lagged 32 points behind in 2005 similar to students in the different SES subgroups. Two-thirds of special education students in 2005 scored in the below basic achievement level as compared to over one-third of regular education students (Table 16).

Table 15

Science Scores by Special/Regular Education Classification

	Year		
	1996	2000	2005
Special education	113	118	120
Regular education	151	152	152

Note. Total points possible =300.

Table 16

Science Percentages by Special/Regular Education Classification and Achievement Levels

	2007			
	Below basic	Basic and above	Proficient and above	Advanced
Special education	73	27	8	<1
Regular education	38	62	31	<1

Note. Total points possible =300.

The NAEP data presents a persistent trend of discrepancies in the scores of subgroups, whether race, gender, SES, or special education classification in the areas of mathematics and science. These national data were alarming in almost all areas of 8th grade mathematics and science, but Alabama scores for the same period were below the national averages in all of the subgroups: race, gender, and SES. Although no data were found on the NAEP website comparing the states' scores for students with disabilities data for the other subgroups were presented (Grigg et al., 2005; Lee et al., 2007). When scores were compared, Alabama was 49th in the nation in 2007 in mathematics and was tied with three other states for 45th place in 2005 in science. Not only did Alabama have some of the lowest scores in the nation, but also had equal or larger discrepancies between the subgroups' scores than the national average (Grigg et al.; Lee et al).

Mathematics and Science Curriculum

An examination of the NAEP data in the mathematics and science subject areas indicates serious issues associated with student achievement especially considering the gaps among various subgroups (Grigg et al., 2005; Lee et al., 2007). With advances in learning theories, technology, and support equipment, such as school computer labs, it could be assumed improvements would have occurred in reducing the achievement gaps found among the various subgroups. Although improvements were made in the average scores of students in mathematics, no appreciable change was observed in the gaps between the subgroups. In science, not only was there no reduction in gaps found among the various subgroups, but there was little change in overall scores which have remained stagnant for over a decade (Grigg et al.; Lee et al.). The question that arises at this point is not if there is a problem, but where does the problem lie. Curricula forms the foundation for any educational system so the following section will review literature related to curricula in public schools in the United States.

Project 2061: Science for all Americans was an initiative founded by the American Association for the Advancement of Science (AAAS, 1993) to conduct research concerning the mathematic, science, and technology literacy of Americans. *Project 2061* created a large team of experts composed of: elementary, middle, and high school levels teachers; school administrators; engineers; scientists; mathematicians, historians, and learning experts (AAAS). This team's task was to formulate a blueprint which identified the skills and knowledge children should possess in mathematics, science, and technology by grade level. The goal was not to dictate a set curriculum for all children but instead to provide schools and school systems with guidelines to identify what is reasonable to expect children in these subject areas to learn at specific grade levels (AAAS).

The taskforce discovered a gap between what American students at various ages were considered capable of and should be learning and what they actually knew (AAAS, 1993). Moreover, the results of Project 2061 indicated that many children did not understand the processes and concepts of mathematics, science, and technology (AAAS, 2001). According to *Project 2061*, the educational system in the U.S. was stressing memorization rather than problem-solving and critical-thinking skills (AAAS, 2001; AMSTI, 2008). The study indicated that students may have been able to recite the correct words and facts, appearing to be functional, but lacked in-depth understanding.

Another analysis was conducted by the Trends in International Mathematics and Science Study (TIMSS), an international study conducted by the United States Department of Education using NAEP data (USDE, 2008). TIMMS compares education in the United States to that of other nations across the globe. When the study compared the U.S. curricula to those in nations whose students scored higher in mathematics and science, results indicated that the curricula in these subjects in the U.S. covered too much material, lacked thoroughness, and emphasized direct teaching, which is comprised mainly of lecture, when compared to curricula of other more academically successful nations' educational systems (AMSTI, 2000; USDE). Additionally, mathematic and science education in the United States was found to be predominately teacher-orientated while the other nations' educational systems were considered more student-orientated (AMSTI).

Educational experts have harshly criticized public education in the United States as being overly demanding in quantity and allowing the quality of learning to diminish. According to Wheeler (2006), national science standards recommended for primary and secondary levels, which span only 13 years, would require approximately 22 years for teachers to present effectively. Another report stated that the United States public school system expected students to be taught an average of 30 topics a year while other more academically successful nations expected on average 20 topics (Cogan & Schmidt, 1999). Although the United States required more mathematics standards to be taught annually than other nations, U.S. students have scored lower on standardized tests than students from other nations requiring fewer standards (Cogan & Schmidt; Valverde & Schmidt, 2006).

Concern exists that the breadth of objectives teachers are required to cover in the classroom reduces curricular depth and results in a lack of coherence and mental challenge for students (Valverde & Schmidt, 2006). Requiring more content than can be reasonably presented during an academic year results in information being presented too quickly (AAAS, 1993). Cogan and Schmidt (1999) stated that how a subject is taught is more important than how much is taught. Instead of trying to force students to learn ever increasing amounts of information students should be taught to think rather than to memorize the additional information (AAAS).

Alabama Mathematics, Science, and Technology Initiative

In view of the alarming statistics discussed previously in this study, in 1999, the Alabama Superintendent of Education Dr. Ed Richardson and Deputy Superintendent of Education Dr. Joe Morton determined that a need existed in Alabama for a program to increase the achievements levels of students in the areas of mathematics, science, and technology (AMSTI, 2000, 2008). In 2000, a task force was formed composed of K-12 educators, postsecondary educators, and business people (AMSTI, 2000, 2008).

This team of experts selected goals closely aligned with the *Principles and Standards for School Mathematics* (PSSM) developed by the National Council of Mathematics Teachers, the *National Science Education Standards* (NSES) developed by the National Research Council, and the *National Educational Technology Standards* (NETS) and the curricula outlined in the Alabama State Courses of Studies (AMSTI, 2000, 2008). Additionally, teachers were surveyed to determine the greatest classroom needs to ensure that the program could be easily implemented at the school and classroom levels (AMSTI, 2000, 2008). The result was a program, the Alabama Mathematics, Science, and Technology Initiative (AMSTI), that reinforced and supported the Alabama mathematics, science, and technology curricula. This program was funded so that it had adequate supplies and training and is being gradually implemented within Alabama public schools.

In keeping with NCLB guidelines the task force examined research-based learning strategies, resulting in the selection of inquiry-based instruction to be used in the AMSTI program (AMSTI, 2000, 2008). The recommendations of the taskforce included providing a program to Alabama primary and secondary public schools which would bring a hands-on inquiry-based approach to learning in the classroom while aligning with the national standards. This program, AMSTI, includes the use of effective questioning techniques, authentic lessons, and increased meaningful communications (AMSTI, 2000). Because of the importance placed upon the success of Alabama students in the areas of mathematics, science, and technology, the Alabama State Department of Education as of 2009 has provided AMTI to the participating schools through state funding rather than through school district funding (AMSTI, 2008).

AMSTI is being implemented through eleven regional professional development sites that the Alabama State Department of Education had founded throughout the state. These eleven regional professional development sites provide training for all subject areas to Alabama public school teachers, but several of these sites also serve as AMSTI training sites (AMSTI, 2008). Other services provided at the regional sites include on-site support personnel to teachers and provision of materials and supplies necessary for the AMSTI lessons. In 2008, AMSTI was already in place in 40% of Alabama's public schools and the goal for the 2009-2010 school year is to reach 50% of all of Alabama's public schools. Eventually, the ultimate goal of the AMSTI program is to be in all 11 of Alabama's regional professional development sites and to be implemented in all Alabama public elementary and middle schools. The AMSTI program is used in K-8 mathematics and science classes; only the science component, known as Alabama Science in Motion (ASIM), is found in the high schools (AMSTI, 2000, 2008).

Participation by the schools is voluntary and schools must apply to be considered for the program. To be considered for acceptance a school must: 1) have 80% of mathematics and science teachers agree to be AMSTI-trained; 2) have designated personnel willing to become teacher-leaders; 3) have school administrators willing to devote time for professional development throughout the school year; 4) allow teachers time to work on AMSTI activities; and 5) allow AMSTI specialists to visit the school to assist teachers (AMSTI, 2008).

Each teacher who agrees to become an AMSTI teacher must attend two weeks of training during the summer for two consecutive summers (AMSTI, 2008). For mathematics, AMSTI has supplemental materials which are provided to these teachers during their summer training but no other materials are presented afterwards. Instead, teachers are trained to present traditional subject content as inquiry-based lessons. Students may construct blocks to determine surface area or collect data to graph (AMSTI). The mathematics portion of AMSTI is in the teaching methodology rather than in expensive equipment as is found in the science portion. A text which consists of consecutive hands-on activities is issued to the teachers who are then trained in applying the inquiry-based lessons (AMSTI).

For science, teachers are not only trained in inquiry-based instruction, but are also presented with a text book and several large kits each semester that contains the materials necessary for the AMSTI lessons. The kits contain chemicals, glassware, electronic scales, batteries, K'nex to build roller coasters and cars, and any other items needed to complete the activities (AMSTI, 2008). The science portion of AMSTI was developed into units comprised of individual lessons. The units begin with start up activities called anchor lessons that connect to students' prior knowledge. The anchor lessons function as active graphic organizers for the unit's subsequent lessons. The units begin with lessons that present simple, concrete events and progress to more complex problems. During the lessons, students physically interact with problems by performing an experiment, collect data, and form and write conclusions. The accompanying instructions provide structure to the lessons, while open-response questions allow student to be able to formulate their own answers and conclusions. Extensions are also built into the lesson for students who are able and willing to conduct further independent investigations. Inquiry-based assessments, which evaluate gains in students' practical knowledge, are built into the end of each unit. These assessments include multiple choice questions that evaluate students' higher-order thinking skills as well as open-ended short response questions.

AMSTI strongly encourages teachers to have students keep notebooks (AMSTI, 2008).The focus is on written answers which reflect students' thoughts and thinking skills. Students use notebooks not only to store their notes, homework, and class work, but also to write their own thoughts and comments. The notebooks document students' progress made throughout the quarter. Writing activities are strongly supported by Marzano et al. (2001) who advocated for summarizing and note taking as strategies highly successful at promoting student learning. Such strategies were also supported by the 90/90/90 school study which found that an emphasis on student writing was a common characteristic of successful at- risk schools (The Leadership and Learning Center, 2009).

Team work can also be very successful for building knowledge, as well as strong social skills; therefore, many of AMSTI's activities are designed for cooperative group work. Vygotsky (1978) maintained that socialization, such as cooperative learning groups, is a powerful learning tool and motivator. Using meta-analysis to determine effectiveness, Marzano found support for Vygotsky's views and listed cooperative learning as the sixth most successful learning technique.

The Institute for Communication and Information Research at the University of Alabama provides external evaluation for AMSTI and assesses school data to determine the program's success. Data from July 2002 through May 2005 from 75 AMSTI schools in all 20 participating school districts were studied. For comparison, 265 non-AMSTI schools were used as a control group. Data included scores from the Stanford Achievement Test -10th Edition (SAT 10), Alabama Reading and Mathematics Test (ARMT), and Alabama Graduation High School Examination (AHSGE). School-wide data results showed consistent and statistically significant student academic improvement in AMSTI schools (AMSTI, 2008).

Unfortunately, AMSTI data has not been disaggregated by subgroups. Accountability mandates have placed principals under an increasing amount of pressure to find programs and strategies that meet the needs of non-proficient students (Styron, Roberson, Schweinle, & Lee, 2005). Current legislation, specifically NCLB, differs from previous legislation in that it requires proficiency for all student subgroups, not just the majority (USDE, 2004). If any subgroup fails to meet proficiency, the school is flagged as potentially failing. In the state of Alabama, any school which consistently does not meet the NCLB standards is in danger of being taken over and restructured by the State Department of Education. Therefore, any assessment of the effectiveness of AMSTI, or similar programs, should include an analysis of how well the program meets the academic needs of student subgroups. Having detailed information concerning the success of the AMSTI program for different subgroups will assist school leaders in making informed decisions concerning implementation of this program at their schools.

Summary

This review of literature examined the learning theorists, Dewey, Piaget, and Vygotsky, all of whom concluded that students learn through interacting with their environment and agreed that as learners act upon the objects in their environment, they create changes in these objects which in turn produce further learning (Dewey, 1916; Piaget, 1971, 1972; Tryphon & Vonèche, 1996; Vygotsky 1978, 2004). Piaget called this type of learning constructivism (Piaget, 1971). As students consider and analyze the changes, Dewey, Piaget, and Vygotsky asserted that students not only learn about the objects, but also the processes by which the objects change. Inquiry-based learning is founded upon these theories and includes hands-on activities and student reflection on the changes brought about by their actions (Llewellyn, 2002).

This review of literature also examined the national scores of 8th grade students in mathematics and science from *The Nation's Report Card* (Grigg et al., 2005; Lee et al., 2007) and found gaps between several subgroups. While some gaps were minor, others were serious and persistent, having existed over a decade. While national data showed serious problems, the scores of Alabama students were found to be even lower and resulted in Alabama being listed as one of the poorest performing states in 8th grade mathematics and science. Additionally, gaps between the subgroups featured in this present study were equal to or in most cases larger than the gaps found nationally (Grigg et al.).

Finally, this chapter examined AMSTI which was created using inquiry-based learning strategies to enhance and supplement the mathematics, science, and technology curricula in the Alabama public primary and secondary schools. Although the most recent data showed that implementation of AMSTI substantially increased student scores in both mathematics and science, no study has been published on the effect of AMSTI by different subgroups: race, gender, SES, and special education students or on the teachers' inclusion of inquiry-based lessons (AMSTI, 2008). This study examined the effect of AMSTI on these subgroups as well as the frequency of teacher usage of inquiry-based lessons using data from several Alabama public middle schools. Chapter III describes the methodology, instrumentation, and data analysis used in this study.

CHAPTER III

METHODOLOGY

The purpose of this study was to examine the effect that the implementation of AMSTI had on student scores in mathematics and science in the middle school years, as well as, teacher usage of inquiry-based lessons and belief in the efficacy of those lessons. Specifically, this study sought to answer the following research questions:

1. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades?
2. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by gender in 6th, 7th, and 8th grades?
3. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students by socioeconomic status in 6th, 7th, and 8th grades?
4. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students in special education versus regular education classification in 6th, 7th, and 8th grades?
5. Do teachers report a significant increase in the number of inquiry-based lessons used in the classroom after being AMSTI trained?
6. Do teachers report a positive increase in their perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained?

Sample

The study used a convenience sample that included students and teachers from five public middle schools located in a single school district in southern Alabama. Convenience sampling was appropriate since this was an exploratory study evaluating the effect of AMSTI in various subgroups that were well-represented overall at both schools (Fraenkel & Wallen, 1996). A disadvantage to convenience sampling was that the sampling was not random, but these samples included student populations from two separate schools that had large student and teacher populations. The participating schools were selected based upon having full implementation of AMSTI programs within four years prior to this study and the student subgroup populations being sufficiently large so as to provide meaningful results. Demographic data on the schools were obtained from the Alabama State Department of Education (Alabama State Department of Education [ASDE], 2009a).

Setting. The middle schools which participated in this study were part of a single school district in Alabama. The school district was one of the largest in the nation and was county-wide during the time in which this study was conducted (Alabama State Department of Education [ASDE], 2009a). The county had one mid-sized city, which was surrounded by several smaller cities and several large rural areas. Table 17 provides demographic data from the 2007 – 2008 school year for the school district and each school (ASDE, 2009a, 2009b).

School A was considered a suburban school with a student enrollment of approximately 1426 students in the 2007 – 2008 school year (Table 17) distributed between 6th, 7th, and 8th grades with populations of: 446, 430, and 545, respectively.

School B was a rural school with a student enrollment of approximately 759 that was divided between the three grades, 6^{th} – 8^{th}, with enrollment of 267, 250, and 242, respectively. School C was also considered suburban with a student enrollment of approximately 1147 that was divided between the same three grade levels with enrollment of 360, 389, and 398, respectively. School D, the only inner-city school in the study, was the smallest of all the schools studied with a student population of approximately 258 which was divided between grades 6^{th} – 8^{th}, with enrollments of 74, 93, and 91, respectively. School E was considered a suburban school and had a student enrollment of approximately 1481 students (Table 17) also distributed roughly equally between 6th, 7th, and 8th grades with populations of: 490, 484, and 507, respectively (ASDE, 2009a, 2009b).

Schools A, B, C, and E had a much smaller black population than the school district (Table 17). School D was the exception with a black student population of 96%, which was larger than the district's. Schools B, C, and E's percentages of students eligible for free/reduced lunch were roughly the same as the school district average while School A's percentage of eligible students was slightly lower and School D's percentage was much higher. Since gifted students are by definition high-achieving students, this study placed special education students who were classified as gifted with the regular education students. Once this adjustment was made, resulting percentages of special education students for all schools were higher than the school district average. School D had the largest percentage of special education population.

Table 17

School Demographics

		School District		School A		School B	
				Schools			
		N	%	N	%	N	%
Population		63,424	100	1,421	100	759	100
Race	White	28,844	46	945	67	638	84
	Black	31,478	50	398	28	85	11
	Hispanic American	808	1	27	2	10	1
	Native American	634	<1	2	<1	4	<1
	Asian American	1,415	<1	38	3	21	3
Gender	Female	31,074	49	663	47	355	47
	Male	32,350	51	758	53	403	53
SES by Free/Reduced Lunch	Eligible	41,510	65	597	42	451	59
	Ineligible	21,914	35	824	58	307	41
Classification [a, b]	Special education	4,164	7	154	11	99	13
	Regular education	59,260	93	1,267	89	660	87

Table 17 (continued).

		Schools					
		School C		School D		School E	
		N	%	N	%	N	%
Population		1,147	100	258	100	1,481	100
Race	White	839	73	8	3	1261	85
	Black	268	23	248	96	186	13
	Hispanic American	7	<1	0	0	23	2
	Native American	5	<1	0	0	6	<1
	Asian American	24	2	1	<1	5	<1
Gender	Female	567	49	133	52	702	47
	Male	580	51	125	48	779	53
SES by Free/Reduced Lunch	Eligible	793	69	224	87	857	58
	Ineligible	354	31	34	13	624	42
Classification [a, b]	Special education	154	13	42	16	193	13
	Regular education	993	87	216	84	1,288	87

[a] Data were collected from the school district's department of Student Support Services.
[b] Percentage excludes students classified as gifted.

Although the student demographics of each school did not perfectly reflect the school district's student population in each subgroup, all had sufficient populations to be representative of diverse student subgroups, as well as, to provide meaningfully sized subgroups. School A was used for both the CRT assessment instrument and the teacher questionnaire. Schools B, C, and D were used solely for the teacher questionnaire. School E was used for the CRT assessment and the pilot test on the survey instrument.

This study examined the mathematics and science CRT scores of a group of students across a period of three years. This student-level longitudinal data formed three groups: scores from all students while in the 6th grade when they received no AMSTI intervention; scores from those same students who received one semester of AMSTI intervention in 7th grade; and scores from those same students who received two semesters or a full year of AMSTI intervention in 8th grade. Students were subsequently categorized by the subgroups: race, gender, SES, and special/regular education. Middle schools included in this study had recently implemented AMSTI. Students in this study were in the 6th grade prior to the time their school implemented AMSTI. The program was then implemented incrementally with one semester the first year and two-semesters the second year.

Only students whose mathematics and/or science teachers attended AMSTI training were included in this study. AMSTI was implemented and, therefore, assessed only in mathematics and science. To determine which students should be included in this study, the students' teachers were categorized by whether they received appropriate AMSTI training during the three years of this study: no AMSTI training during the first year, one summer of training during the second year, and two summers of training in the third year. Data were obtained from the AMSTI program to determine which teachers were AMSTI certified and the years of their certification.

Table 18 shows the student and teacher populations at the schools which participated in the portion of the study using the AMSTI Teacher Questionnaire. School

A, as previously mentioned, was used in both the CRTs and the teacher questionnaire portions of the study. Schools B, C, and D participated only in the questionnaire. School size ranged from 258 (School D) to 1421 (School A). School A and School C were considered suburban schools, School B rural, and School D inner-city.

Table 18

School Demographics for Teacher Questionnaires

	Schools			
	A	B	C	D
Student Enrollment	1,421	759	1,147	258
Number of Mathematics and Science Teachers	22	14	13	4

Instruments

CRTs

Information on test administration of the CRTs was derived from interviews with a test administrator and subject supervisor from the school district, both of whose names were withheld due to confidentiality concerns. Student test scores in this study were derived from criteria referenced tests (CRTs), which each school administers. The CRTs were uniformly created, distributed, and assessed through the school district's central office. Subject area supervisors at the central office with the help of classroom teachers developed and edited CRT test questions to create test banks for the CRTs. Test questions were then selected from these test banks each quarter. CRTs were specific and appropriate for each grade level's objectives. CRTs also were correlated with the Alabama Courses of Study, a listing of all objectives required by the state that students must be taught per subject area and grade level. All CRT questions were multiple-choice. Scores were based upon a 100-point scale. Due to confidentiality issues, sample questions from either test were not available for review. Procedures for administrations of the CRTs were standardized. Tests were kept secure at the school district's central office and retrieved by the school's test coordinator prior to each test administration. At each school, tests were counted and signed out by the teachers from the test coordinator each morning and returned after testing was completed at the end of each day. This procedure was repeated daily until testing was completed. Students answered tests using scantron sheets, which were subsequently computer scored and downloaded into a software program called Testtrax (EduTrax, 2009).

The school district issued study guides to teachers each year from 2005 – 2008 that indicated which learning objectives should be taught and subsequently tested each quarter. Science study guides consisted of CRT test bank questions with answers. Mathematic study guides consisted of problems and questions comparable to CRT test.

AMSTI Teacher Questionnaire

The fifth research question posed by this study states: Does the use of AMSTI increase the teacher-reported number of inquiry-based lessons taught? The sixth research question asks: Does the use of the AMSTI program create a positive increase in teachers' reported perceptions of the efficacy of the use of inquiry-based lessons? To answer these questions, the researcher developed a survey instrument, the AMSTI Teacher Questionnaire (Appendix A), to compare the quantity of inquiry-based lessons used by participating teachers, as well as teachers' perception of the value of inquiry-based lessons. Face and content validity was established through review by the Science Supervisor of the school district in which this study was conducted as well as an AMSTI director/mathematics specialist. Reliability for the pilot was set at a Cronbach's alpha of .70.

Pilot survey instrument. The pilot survey instrument consisted of twenty-four questions. The first eight questions collected demographics. The remaining questions used a Likert scale, ranging from strongly disagree to strongly agree, that measured three constructs concerning teachers' pedagogical beliefs concerning: the effect of inquiry-based lessons on student learning, cooperative learning, and students' reflection on lessons. Additionally, four of these questions measured the frequency of usage of inquiry-based lessons pre- and post-AMSTI implementation. Change in teachers' reported use of inquiry-based lessons should reflect and support teachers' beliefs in the efficacy of inquiry-based lessons.

The pilot survey instrument was distributed to a group of mathematics and science teachers at School E where the researcher was employed at the time of the study. For this reason, School E was excluded from the study in regards to data collection using the teacher questionnaire. The school had participated in AMSTI for almost three years and had full implementation with AMSTI being used throughout the current school year. Permission was granted by the principal to conduct the pilot (Appendix B). Following IRB approval (Appendix C), the pilot was printed on pale green paper with a small note attached indicating a two day deadline and asking teachers to return the questionnaire to the researcher's faculty mail box. It was subsequently distributed by the researcher personally to each teacher who was fully trained in the AMSTI program. Ten out of 22 or 45% of the teachers completed and returned the questionnaires.

Some of the teachers provided feedback through the questionnaire by writing comments on the instrument while another teacher discussed concerns verbally with the researcher. The researcher sought additional feedback from two of the veteran teachers who participated in the pilot. Based upon provided feedback, all questions using the word "inquiry" were changed to "inquiry-based". Question 1, which asked at which school the teacher taught, was replaced by a question asking teachers for the number of years of AMSTI training each had received because of concerns that teachers would feel their anonymity was compromised. Because one respondent did not complete the back of the survey instrument, a comment was added to the footnote that the questionnaire continued on the back of the paper.

Questions 9, 13, 17, and 21 were not analyzed for a Cronbach's alpha because they compared average frequency of inquiry-based lessons and did not represent a construct. The time frame referenced for questions 9 and 13 was for the previous four years whereas questions 17 and 21 measured current usage. Question 17 was reversed from the other three questions and therefore was reverse coded. The means for Questions 9 and 13 were similar to each other as expected as were the means for Questions 17 and 21.

Data collected from the other questions on the pilot were entered into a SPSS data base to determine the Cronbach's alphas for internal reliability for each construct: effect of inquiry lessons, cooperative learning, and reflection. The reliability index for the effect of inquiry lessons (Questions 8, 12, 16, 18, and 22) was a Cronbach's alpha of .379. When Question 22 was deleted, Cronbach's alpha increased to .917. A few of the teachers participating in the pilot testing either left this question blank or inserted a question mark in the margin indicating some confusion of the terminology "authentic" used in Question 22. After discussing the problem with some of the teachers, the word "authentic" was replaced with "problems found in everyday life." Once Question 22 was edited, it was inserted into the QUAID software at the University of Memphis' website (University of Memphis, 2009). This software analyzes survey questions for possible problems based upon syntax identifying language that is too technical or too vague, or that is ambiguous. According to QUAID, the edited version of Question 22 was acceptable.

The second construct was cooperative learning (Questions 10, 14, 19, and 23) and its Cronbach's alpha, was .616. Upon deleting Question 23, Cronbach's alpha was .910. When Question 23 was inserted into QUAID, the software indicated that the word "retention" might have been unfamiliar to some of the respondents so it was changed to "understanding" (University of Memphis, 2009). When the question was inserted into QUAID software, the edited Question 23 was acceptable.

The third construct, reflection (Questions 11, 15, 20, and 24), had a Cronbach's alpha of .560. When Question 24 was deleted, Cronbach's alpha was .761. Question 24 was run through QUAID and also was found to have a problem with the word "retention" which was simply omitted from this question. QUAID also cited the term "notebook" as problematic and it was also omitted and the word "journals" retained (University of Memphis, 2009). The Cronbach's alpha for the overall survey instrument (Questions 8 – 21, exclusive of Questions 9, 13, 17, and 22 and using the recoded Question 11) was .918 which met the minimum requirement set by this study of $\geq .70$ for reliability.

Procedure

CRT Data Collection

The researcher contacted the Assistant Superintendent of Curriculum from the school district and requested permission to conduct this study. Per instructions, a letter was written explaining the study and its purpose and submitted to the Assistant Superintendent who then obtained the Superintendent's permission (Appendix D). After approval by the dissertation committee was granted, approval to conduct this study was obtained from the Human Subject Review Board at The University of Southern Mississippi (Appendix E).

To collect the mathematics and science CRT scores, the personnel from the informational services department at the participating school district referred the researcher to the data company, TestTrax, which was on contract with the school district (EduTrax, 2009). The company, upon request, compiled student demographics, course teachers' names, and mathematics and science CRT scores for School A and School E in an Excel file and transmitted the data electronically to the researcher. Each student's individual score was a separate case resulting in an Excel file with 20,716 cases. Upon receipt, the data were reorganized and transferred into SPSS. Once reorganized, each case represented one student with a possibility of up to 11 scores. This resulted in a total of 1408 cases. The data subsequently were stripped of student names and the teachers' names were recoded to maintain anonymity.

Student CRT scores in mathematics and science were collected for all four quarters for each school year from 2005 – 2008 for grades 6 through 8 for School A and School B with the exception of the first quarter for the 2005 – 2006 school year. As a result of Hurricane Katrina making landfall on August 29, 2005, school schedules were disrupted and the school district's central office did not administer CRTs for first quarter for the 2005 – 2006 school year. Testing, however, resumed at second quarter and was available for this study.

To identify teachers who were AMSTI trained, a list of teachers' names was obtained from the TestTrax data (EduTrax, 2009). These names were sent to the AMSTI local state professional development site. With verbal permission from the Alabama State Department of Education, AMSTI provided information indicating which of the listed teachers were AMSTI trained by year. Teachers' names were subsequently dummy-coded in SPSS according the number of years of AMSTI training received. Data for the 913 students who had not been instructed by AMSTI trained teachers during the timeframe of this study were excluded. This procedure resulted in a sample size of 495 students.

Data analysis for CRTs. CRT data and teachers' AMSTI training status were loaded into a SPSS database. Independent variables (IVs) were race, gender, socioeconomic status, and special education classification. The dependent variables (DVs) were participants' CRT scores in mathematics and science for the repeated measures design. Three multivariate analysis of covariance (MANCOVA) and one multiple analysis of variance (MANOVA), each with the two DVs, students' mathematics and science CRT scores, were run; one MANCOVA was run for each IV while controlling for gender as the covariate, to determine whether a student's race, gender, SES, or special/regular education classification interacted with CRT mathematics and science scores. Gender was the only covariate because it was the only IV that did not violate the assumption of pre-existing group differences. Appropriate planned contrasts were conducted. Data also were screened for outliers and violations of statistical assumptions.

AMSTI Teacher Questionnaire Data Collection

The edited version of the AMSTI Teacher Questionnaire (Appendix G) was administered to mathematics and science teachers at the schools participating in this study. Paper copies of the questionnaire were hand-delivered by the researcher to the questionnaire distributors along with a cover letter (Appendixes F and G). An educator at each site, specified by the researcher, distributed the questionnaires during faculty and/or team meetings. AMSTI trained mathematics and science teachers were asked to remain after these regularly scheduled meetings to complete the questionnaires. Teachers were informed their participation was voluntary and anonymous. They could return a blank questionnaire if they chose not to participate. To further safeguard anonymity, teachers returned their questionnaires by placing them in a stack that was located away from the proctor. Once all questionnaires were returned, the designated proctor placed all questionnaires in an opaque envelope, sealed it, and returned the envelope to the researcher through school mail.

Data analysis for AMSTI Teacher Questionnaires. Data from the questionnaires were loaded into a SPSS database. Descriptive statistics and frequencies were run. Cronbach's alpha was set at .70 for reliability. An independent *t*-test was run to determine if any significant changes occurred in the frequency of usage of inquiry-based lessons and paired *t*-tests were run to evaluate changes in teachers' perceptions of inquiry. Chapter IV will present the findings.

CHAPTER IV

RESULTS

Chapter III examined the procedures and protocols that were used to address the research questions asked by this study. This chapter examines the resulting data collected from the participating schools in an effort to answer the research questions and to determine whether the hypotheses posed by this study should be accepted or rejected. This study was guided by the following hypotheses:

1. The implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades.
2. The use of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by gender in 6th, 7th, and 8th grades.
3. The use of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students by socioeconomic status in 6th, 7th, and 8th grades.
4. The use of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students with special education ruling compared to students in regular education in 6th, 7th, and 8th grades.
5. The use of the AMSTI program will significantly increase the number of inquiry-based lessons teachers report being used in the classroom after being AMSTI trained.

6. The use of the AMSTI program will significantly increase teachers' reported perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained.

CRT Mathematics and Science Scores

CRT mathematics and science scores were examined to address the following research questions:

1. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades?
2. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by gender in 6th, 7th, and 8th grades?
3. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students by socioeconomic status in 6th, 7th, and 8th grades?
4. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students in special education versus regular education classification in 6th, 7th, and 8th grades?

Table 19 shows the frequencies of the total population of students from both schools participating in this part of the study (School A and School E). As seen in Table 19, the populations from each school were approximately equal in size. Demographics were missing for some of the cases so the percentages do not reflect 100% of the population. Frequencies for gender showed that more males participated (46%) than females (40%). The population was predominately white (65%) with blacks being the largest minority group (18%). Socio-economic status (SES) was reported by eligibility for free/reduced lunch. Students eligible for either free or reduced lunch formed the group designated "eligible" for free/reduced lunch and was a larger group (*n*= 663) than those who were ineligible (*n*= 580). Students identified as gifted were included in the regular education subgroup (75%). All other special education categories were combined resulting in almost 11% total special education population.

Table 19

Demographics From CRT Data: School A and School E

	School A		School E		Total	
	n	%	*n*	%	*n*	%
Enrollment[a]	692	49	716	51	1,408	100
Gender						
Male	345	50	336	47	681	46
Female	294	43	298	42	592	40
Missing	53	8	82	12	215[a]	14
Race						
Asian American	17	2	4	<1	21	1
Black	177	26	82	12	259	18
Hispanic American	9	1	6	1	15	1
Non-specific	3	<1	NA	NA	3	<1

Table 19 (continued).

	School A		School E		Total	
	n	%	*n*	%	*n*	%
White	432	62	540	75	972	65
Native American	1	<1	4	2	5	1
Missing	53	8	82	12	215 [a]	14
SES by Lunch Status						
Eligible	272	39	391	55	663	45
Ineligible	350	51	230	32	580	39
Missing	70	10	95	13	245[a]	17
Education Classification						
Regular Education	558	81	550	84	1,108	75
Special Education	81	12	84	12	165	11
Missing	53	8	82	12	215[a]	14

[a] 80 cases were missing School Id numbers.

Once CRT data were reformatted for SPSS, teachers' names were recoded numerically and then dummy coded by AMSTI training for the years studied. The next step was to select only those cases in which all teachers were trained appropriately. Cases were coded as teachers' with no AMSTI training for the first year of the study, teachers with one summer of training for year two, and teachers with two summers of training for year three. From the original data set, 913 students had taken classes under teachers who were not AMSTI trained, and therefore, were excluded from further analysis. The remaining 495 cases were analyzed for this study.

Within the remaining sample, representation from School A and School E was still approximately equal (Table 20). Also, little change was observed in the percentages of gender and race. The percentage of blacks (% = 17) dropped slightly with a corresponding rise in the percentage of whites (% = 72). The percentage of free/reduced eligible students (% = 42) was less when compared to full pay (% = 50). The percentage of regular education students (% = 88) rose and the percentage of special education students dropped to 5%.

Table 20

Demographics for Students with AMSTI Trained Teachers: School A and School E

	School A		School E		Total	
	N	%	*N*	%	*N*	%
Enrollment	251	51	244	49	495	100
Gender						
Male	115	46	99	41	214	43
Female	123	49	121	50	244	49
Missing	13	5	24	10	37	8
Race						
Asian American	10	4	NA	NA	10	2
Black	55	22	29	12	84	17
Hispanic American	2	1	2	1	4	< 1
Non-specific	1	<1	NA	NA	1	< 1
White	169	67	189	78	358	72
Native American	1	<1	NA	NA	1	<1
Missing	13	5	24	10	37	8

Table 20 (continued).

	School A		School E		Total	
	N	%	N	%	N	%
SES by Lunch Status						
Free/Reduced	85	34	121	50	206	42
Paid	152	61	96	39	248	50
Missing	14	6	27	11	41	8
Education Classification						
Regular Education	227	91	206	84	433	88
Special Education	11	4	14	6	25	5
Missing	13	5	24	10	37	8

Note. N = 1408.
Note. 135 or 9.6% of the participants lacked demographic information.

Due to Hurricane Katrina, first quarter scores were missing for 2005 – 2006. Second quarter scores for both mathematics and science were lower than for any other quarter. Overall, mathematics scores were lower and had higher standard deviations than science scores. The standard deviation for mathematics for the second quarter was larger than for other quarters. On average 6th grade, the year Katrina struck, had the fewest students tested and 8th grade had the most students tested (Table 21 and Table 22). In addition, the second quarter had almost half the number of students tested as was found in any other quarter. SPSS calculated means by excluding all missing data rather than excluding cases with missing data; therefore, SPSS calculated means using all available scores, so students with one or more missing quarters were still retained for the analysis.

Table 21

Students with AMSTI Trained Teachers

Grade	Subject	Year	Quarter	N	Mean	Std. Deviation
6	Mathematics	2005 - 2006	2	187	54.63	22.37
			3	357	74.84	15.32
			4	358	77.70	17.96
7		2006 - 2007	1	400	69.74	17.36
			2	409	68.18	16.21
			3	405	74.3	15.38
			4	407	78.27	13.63
8		2007 - 2008	1	452	70.93	18.09
			2	458	65.53	20.65
			3	485	69.49	19.37
			4	495	77.33	16.66
6	Science	2005 - 2006	2	183	62.44	17.36
			3	358	78.68	13.43
			4	359	73.85	15.83
7		2006 - 2007	1	401	81.15	15.18
			2	410	89.54	10.65
			3	410	88.82	11.67
			4	409	76.81	15.42

Table 21 (continued).

Grade	Subject	Year	Quarter	N	Mean	Std. Deviation
8		2007 - 2008	1	453	79.41	16.22
			2	457	76.79	17.40
			3	484	76.97	16.90
			4	491	81.74	15.85

Table 22

CRT Means for Students with AMSTI Trained Teachers

Grade	Subject	N	Mean	Std. Deviation
6	Mathematics	366	72.40	15.98
7		420	72.34	12.77
8		495	70.61	15.88
6	Science	367	73.54	13.92
7		421	83.83	11.29
8		494	78.52	14.19

The dependent variables (DVs) examined in this study were mathematics and science CRT scores for the same students (repeated measures) in grades 6, 7 and 8. Both DV had several low outliers. The mathematics DV had few low outliers in each grade level. The science DV, though, had several low outliers in each of the subgroups. All CRT scores were scored, recorded, and transmitted electronically, eliminating human error; therefore, none of the outliers were excluded.

The assumption of no pre-existing group differences was tested. Variables which have pre-existing group differences cannot be used as covariates (Field, 2009). If so, then these significant pre-existing differences can overcompensate in accounting for error variance and lower the power of the statistical test (Fields, 2009). ANOVAs were used to test the DVs for the assumption of no group differences (Table 23). Race, SES, and special education classification had pre-existing differences and therefore violated the assumption. SES had one group, 7th science, which did meet the assumption of having no pre-existing group difference, but all other SES subgroups failed to meet the assumptions of no pre-existing group differences; therefore, SES was not used as a covariate. Gender was significant in 8th grade mathematics, but was not significant in all other DVs and therefore was run as a covariate for the three MANCOVAs. Because all other IVs violated the assumption of no pre-existing group differences, gender was analyzed using a MANOVA.

Table 23

ANOVAs for Pre-existing Between Group Differences

Independent Variable	Subject	Grade Level	df	F	Sig.
Race	Mathematics	6	358	4.60	.03
		7	410	13.83	<.001
		8	457	16.82	<.001
	Science	6	358	10.37	.001
		7	411	6.47	.01
		8	457	11.23	.001

Table 23 (continued).

Independent Variable	Subject	Grade Level	df2	F	Sig.
Gender	Mathematics	6	358	.13	.71
		7	410	.002	.97
		8	457	4.08	.04
	Science	6	358	.612	.44
		7	411	.99	.32
		8	457	.22	.64
SES Status	Mathematics	6	355	27.57	<.001
		7	407	7.74	.01
		8	453	10.15	.002
	Science	6	355	12.03	.001
		7	408	.781	.38
		8	453	5.39	.02
Special/Regular Education Classification	Mathematics	6	358	33.10	<.001
		7	410	12.55	<.001
		8	457	3.85	.05
	Science	6	358	37.58	<.001
		7	411	8.85	.003
		8	457	15.99	<.001

Race

When marginal estimated descriptive statistics were examined, differences were observed in the means between the races. Estimated marginal CRT means (Table 24) revealed that whites scored higher than blacks in each grade level in both mathematics and science. The marginal means produced by the MANCOVA run with race as the IV (Table 25) also indicates very little change across the grade levels while science rose markedly from 6th to 7th grade, dropped in 8th grade, although the mean remained higher than 6th grade.

Table 24

CRT Estimated Marginal Means by Race

Subject:	Race	Mean	Std Error
Mathematics	White	73.32	.69
	Black	68.58	1.68
Science	White	79.93	.63
	Black	75.18	1.54

Table 25

CRT Estimated Marginal Means by Grade

Subject	Grade	Mean	Std Error
Mathematics	6	71.01	1.19
	7	71.03	.96
	8	70.82	1.13

Table 25 (continued).

Subject	Grade	Mean	Std Error
Science	6	71.61	1.03
	7	83.12	.87
	8	77.93	1.08

A mixed design MANCOVA was used to address research question one: Does the application of AMSTI create a statistically significant difference in the mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades? Box's Test of Equality of Covariances, Levene's Test of Equality of Error, and Mauchly's Test of Sphericity were conducted to test for violations of assumptions. Box's Test of Equality of Covariances indicated that the assumption of homogeneity of covariances was met, $F(21, 27474.47) = 1.50, p = .07$.

In addition, Levene's Test of Equality of Error Variances indicated that the assumption of homogeneity of variances was met for all grade levels with $F(1, 344) = .002, p = .96$ for 6th grade mathematics, $F(1, 344) = .96, p = .33$ for 7th grade mathematics, $F(1, 344) = .02, p = .89$ for 8th grade mathematics, $F(1, 344) = 2.20, p = .14$ for 6th grade science, $F(1, 344) = 1.16, p = .28$ for 7th grade science, $F(1, 344) = .89, p = .35$ for 8th grade science.

Mauchly's Test of Sphericity indicated that the assumption of sphericity between the within groups was not met for mathematics, $W = .92$, $\chi2(2) = 29.39, p < .001$. Mathematics violated the assumption and, therefore, the degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\epsilon = .95$ for mathematics). Science, with $W = .98$, $\chi 2(2) = 5.71$, $p = .06$, did meet the assumption of sphericity and needed no correction.

A mixed design MANCOVA was run using gender as a covariate. Roy's Largest Root was selected to determine probability because it focuses mainly upon the DV being tested, which increases the power of the test (Field, 2009). Multivariate tests using Roy's Largest Root found a statistically significant increase in the within-subjects grade, $F(4, 340) = 40.34$, $p < .001$. Examination of the means revealed that scores increased from 6th to 8th grade. Using Huynh-Feldt and Bonferroni corrections, the change in mathematics scores by grade level was not statistically significant with $F(1.87, 640.81) = .67$, $p = .50$. Using just the Bonferroni correction and with sphericity assumed, the main effect for science, though, was statistically significant with $F(2, 686) = 61.26$, $p < .001$. No interaction occurred between race and grade, $F(4,340) = 1.45$, $p = .22$.

Simple planned contrasts for grade compared each subsequent year to the initial year of 6th grade in which teachers had no AMSTI training. In science, planned contrasts showed a significant difference regardless of race between 6th grade science CRT scores (with no AMSTI implementation) and 7th grade CRT scores (with half a year AMSTI implementation), $F(1, 343) = 132.79$, $p < .001$, as well as a significant difference between 6th grade and 8th grade (with one year AMSTI implementation), $F(1, 343) = 31.65$, $p < .001$.

Testing the between-subjects factor of race, when controlling for gender, multivariate tests using Roy's Largest Root found that a statistical difference between the mean scores of the races with $F(2, 342) = 4.27$, $p = .02$. Using the Bonferroni correction, univariate tests found the main effect of both mathematics and science to be not significant with $F(1.85, 640.81) = 3.13, p = .05$ and $F(2, 686) = 1.06, p = .35$, respectively. Examination of means in Table 26 found that, controlling for the effect of gender, the differences between the races of both CRT mathematics and science means decreased from 6th to 7th grade and then increased from 7th to 8th.

Table 26

Estimated Marginal Means for Mathematics and Science for Race and Grade Interaction

Subject	Race	Grade Level	Mean	Std. Error
Mathematics	White	6	73.62	.91
		7	73.13	.73
		8	73.22	.86
	Black	6	68.41	2.2
		7	68.92	1.77
		8	68.43	2.09
Science	White	6	74.92	.78
		7	84.42	.67
		8	80.44	.82
	Black	6	68.31	1.91
		7	81.82	1.62
		8	75.42	1.99

The gap between whites and blacks was found to be significantly reduced, but statistically, this reduction cannot be attributed to either mathematics or science; so while statistically significant, this finding is not particularly meaningful with regard to resulting implications. This study, therefore, found that the hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades was not supported.

Gender

Gender showed very little difference in CRT estimated marginal means for mathematics or science. Table 27 shows that males outscored females in mathematics and science. The means for male and female were very close except in 8th mathematics where the CRT scores of males rose while those of females lowered. Overall, mathematics means decreased each year. The estimated marginal means for subject by grade level produced by the MANOVA run with gender as the IV (Table 28) also shows that the mathematics means decreased slightly from 6th grade to 8th. Science means increase from 6th grade to 7th, then, decreased from 7th to 8th grade (Table 28).

Table 27

Estimated Marginal Means by Gender

Subject:	Grade	Mean	Std Error
Mathematics	Male	73.63	.86
	Female	71.79	.94
Science	Male	79.37	.79
	Female	79.21	.86

Note. N = 193 for males and 161 for females.

Table 28

Estimated Marginal Means by Grade Level

Subject	Grade	Mean	Std Error
Mathematics	6	72.99	.83
	7	72.66	.67
	8	72.47	.79
Science	6	74.08	.72
	7	84.00	.61
	8	79.79	.75

Note. N = 193 for males and 161 for females.

A mixed design MANOVA was used to address research question two: Does the application of AMSTI create a statistically significant difference in the mathematics and science scores achieved by students by gender in 6th, 7th, and 8th grades? Box's Test of Equality of Covariances, Levene's Test of Equality of Error, and Mauchly's Test of Sphericity were conducted to test for violations of assumptions. Box's Test of Equality of Covariances indicated that the assumption of homogeneity of covariances was met, $F(21, 425909.11) = 1.05$, $p = .39$.

In addition, Levene's Test of Equality of Error Variances indicated that the assumption of homogeneity of variances was met for all grade levels with $F(1, 352) = .08$, $p = .78$ for 6th grade mathematics, $F(1, 352) = 1.56$, $p = .21$ for 7th grade mathematics, $F(1, 352) = 1.34$, $p = .25$ for 8th grade mathematics, $F(1, 352) = .15$, $p = .70$ for 6th grade science, $F(1, 352) = .58$, $p = .45$ for 7th grade science, $F(1, 352) = .10$, $p = .76$ for 8th grade science.

Mauchly's Test of Sphericity indicated that the assumption of sphericity between the within groups was not met for mathematics, $W = .92$, $\chi2(2) = 28.89$, $p < .001$. Mathematics violated the assumption and, therefore, the degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (€ = .93). Science, with $W = .99$, $\chi^2(2) = 5.39$, $p = .07$, did meet the assumption of sphericity and needed no correction.

A mixed design MANOVA was used rather than a MANCOVA. Although the researcher initially proposed to use a MANCOVA, when the IVs were checked for violations of the assumption of the independence of covariate and treatment effect, it was found that all IVs except gender violated this assumption. Therefore, none of the other IVs could be used as covariates because of pre-existing group differences. Consequently, a MANOVA rather than a MANCOVA was run on gender. Multivariate tests using Roy's Largest Root found a statistically significant difference for the within-subjects grade, $F(4, 349) = 81.26$, $p < .001$. Examination of the means reveals that though mathematics means decreased only slightly from 6th to 8th grade, science means had a definite increase. Using Huynh-Feldt and Bonferroni corrections, mathematics for grade was not statistically significant with $F(1.87, 657.63) = .26$, $p = .78$. With sphericity assumed, the main effect for science, though, was statistically significant with $F(2, 704) = 114.34$, $p < .001$. Simple planned contrasts for grade compared each subsequent year to the initial year of 6th grade in which teachers had no AMSTI training. In science, planned contrasts showed a significant increase between 6th grade science CRT scores (with no AMSTI implementation) and 7th grade CRT scores (with half a year AMSTI implementation), $F(1, 352) = 244.30$, $p < .001$, as well as a significant increase between 6th grade and 8th grade (with one year AMSTI implementation), $F(1, 352) = 67.08$, $p < .001$.

Multivariate tests with Roy's Largest Root indicated that a statistically significant interaction occurred between gender and grade, $F(4, 349) = 2.99, p = .02$. When the univariate tests were examined using the Bonferroni correction, the main effect of science for gender and grade was found statistically significant with $F(1.87, 657.63) = 3.84, p = .03$. Using the Bonferroni correction and Huynh-Feldt, univariate tests found the main effect of mathematics for gender and grade not statistically significant with $F(2, 704) = 1.35, p = .26$, respectively (Figure 1).

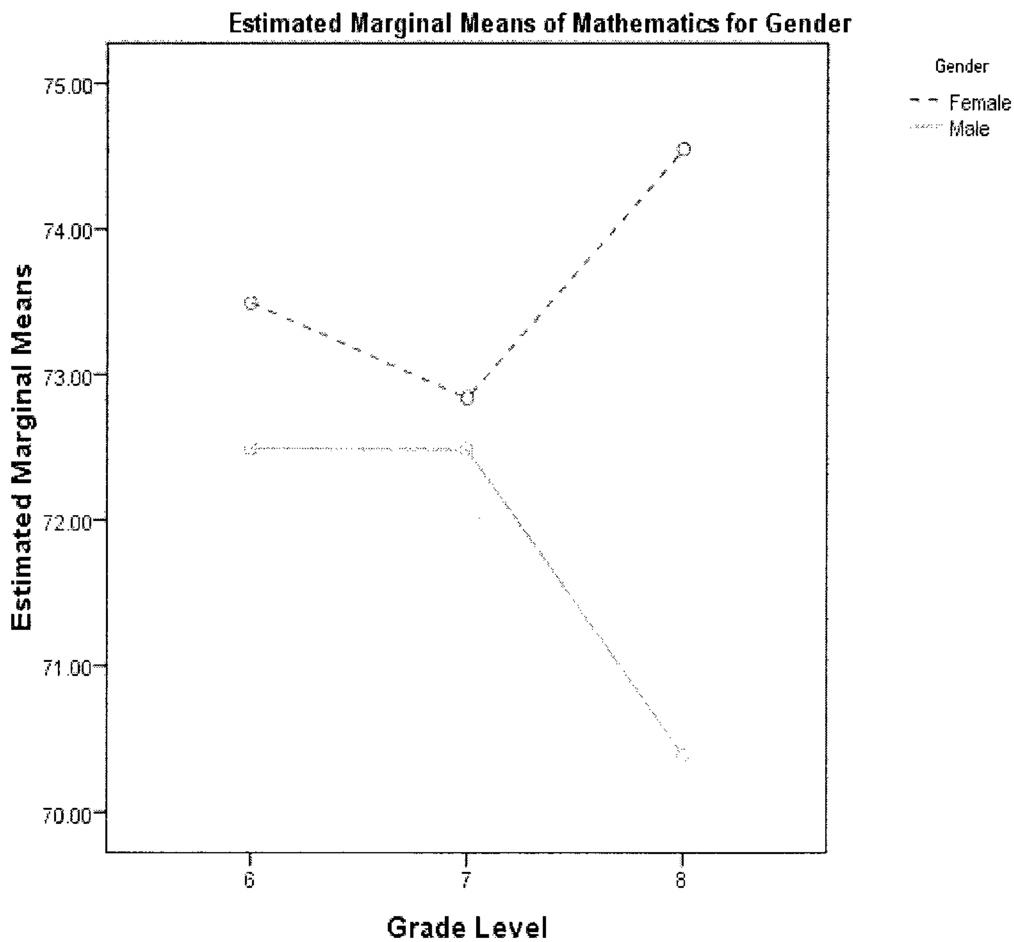

Figure 1. Interaction Graph for Grade v. Mathematics by Gender.

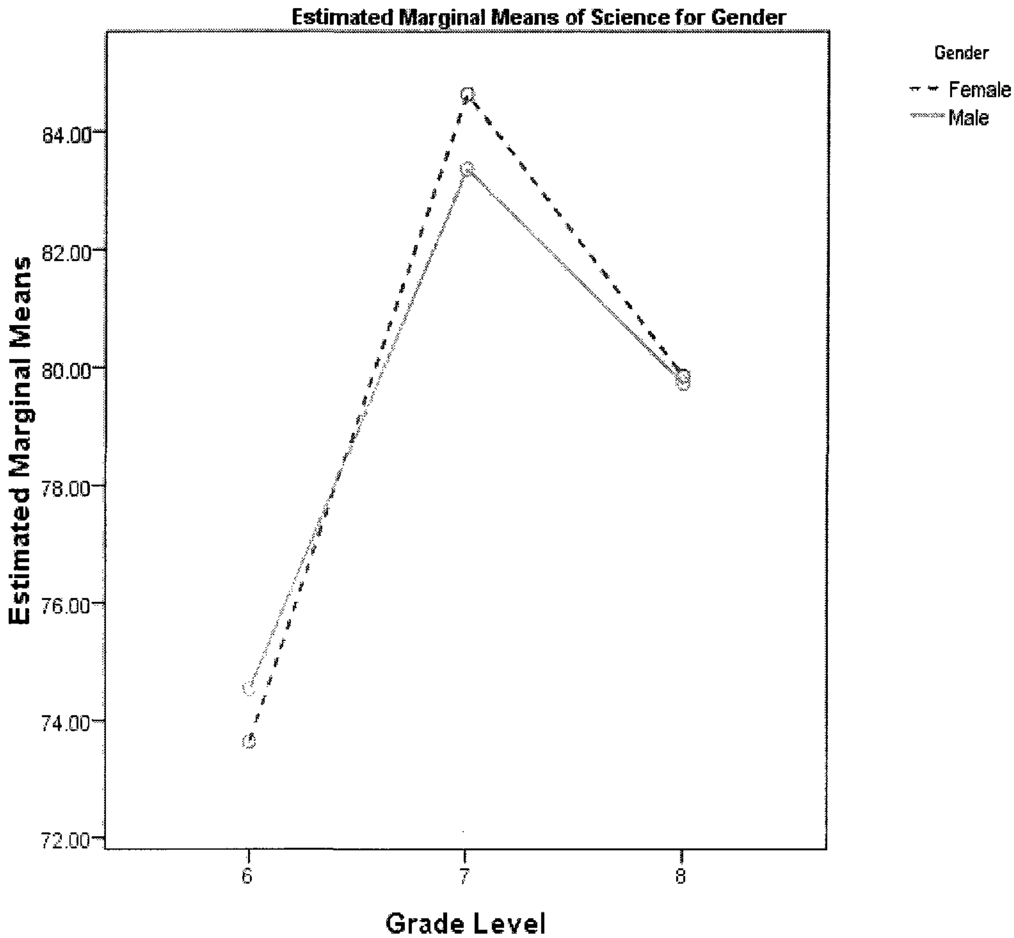

Figure 2. Interaction Graph for Grade v. Science by Gender.

Examination of the interaction graph (Figure 1) as well as the means in Table 29 shows that the difference in the mathematics means between the genders decreased between 6th and 7th grade and then increased between 7th and 8th with means for females increasing and males decreasing. The increase between 7th and 8th grades was greater than the decrease between 6th and 7th. The graphs and means for science (Table 29 and Figure 2) also showed that the difference in science means between the genders for science increased sharply between 6th and 7th grade and decreased in 8th. Overall, science scores increased and the difference between genders decreased. Females in 6th grade scored lower than males, but outscored males in 7th and 8th grades.

Table 29

Estimated Marginal Means for Gender and Grade Interaction

Subject	Gender	Grade	Mean	Std. Error
Mathematics	Male	6	73.49	1.13
		7	72.84	.91
		8	74.55	1.06
	Female	6	72.49	1.23
		7	72.48	.99
		8	70.39	1.16
Science	Male	6	73.64	.98
		7	84.63	.82
		8	79.85	1.01
	Female	6	74.52	1.07
		7	83.36	.90
		8	79.73	1.11

Testing the between-subjects factor of gender, multivariate tests using Roy's Largest Root found no statistical significance difference with $F(2, 351) = 2.11$, $p = .12$. A statistically significant increase was found between the grades, but no statistically significant difference was found between the genders. The hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades, therefore, was rejected.

SES

Examination of the estimated marginal means in Table 30 showed that students ineligible for free/reduced lunch consistently scored higher in both mathematics and science than eligible students. The estimated marginal means for subject by grade level produced by the MANCOVA with SES as the IV (Table 31) also shows that the mathematics means decreased slightly from 6th grade to 8th. Science means revealed the same pattern as previously discussed with the means increasing from 6th to 7th, and then decreased in 8th grade (Table 31).

Table 30

CRT Estimated Marginal Means by SES Status

Subject	Status	Mean	Std Error
Mathematics	Free/reduced lunch ineligible	75.00	.83
	Free/reduced lunch eligible	69.67	.95
Science	Free/reduced lunch ineligible	80.47	.77
	Free/reduced lunch eligible	77.56	.88

Note. N = 200 for Free/reduced lunch eligible and 151 for Free/reduced lunch ineligible.

Table 31

CRT Estimated Marginal Means by Grade Level

Subject	Grade	Mean	Std Error
Mathematics	6	72.44	.81
	7	72.35	.67
	8	72.22	.79

Table 31 (continued).

Subject	Grade	Mean	Std Error
Science	6	73.58	.72
	7	83.92	.61
	8	79.54	.76

Note. N = 351.

A mixed design MANCOVA was used to address research question three: Does the application of AMSTI create a statistically significant difference in the mathematics and science scores achieved by students by SES in 6th, 7th, and 8th grades? Gender was run as a covariate. Box's Test of Equality of Covariances, Levene's Test of Equality of Error, and Mauchly's Test of Sphericity were conducted to test for violations of assumptions. Box's Test of Equality of Covariances indicated that the assumption of homogeneity of covariances was not met, $F(21, 382823.41) = 2.16, p = .002$.

In addition, Levene's Test of Equality of Error Variances indicated that the assumption of homogeneity of variances was not met for most of the grade levels with $F(1, 349) = 14.08, p < .001$ for 6th grade mathematics, $F(1, 349) = 4.30, p = .04$ for 7th grade mathematics, $F(1, 349) = 6.99, p = .01$ for 8th grade mathematics, $F(1, 349) = 15.85, p < .001$ for 6th grade science, and $F(1, 349) = 5.72, p = .02$ for 8th grade science. The exception was 7th grade science which met the assumption of homogeneity of variances with $F(1, 349) = 1.68, p = .20$. F_{max} tests were subsequently run on the means of the CRT scores which failed to meet the assumption of homogeneity of variance using Levene's (Field, 2009). All were found to meet the assumption of homogeneity of variances with F_{max} test scores below 2; F_{max} tests = 1.63, F_{max} tests = 1.35, F_{max} tests = 1.3, F_{max} tests = 1.82, and F_{max} tests = 1.46, respectively.

Mauchly's Test of Sphericity indicated that the assumption of sphericity between the within groups was met for neither mathematics, $W = .93$, $\chi 2(2) = 25.05$, $p < .001$ nor science, with $W = .98$, $\chi^2(2) = 6.30$, $p = .04$. The degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (Є = .95 for mathematics and Є = .99 for science)

A mixed design MANCOVA was run using gender as the covariate. Multivariate tests using Roy's Largest Root found a statistically significant increase for the within-subjects grade, $F(4, 345) = 52.78$, $p < .001$. Using Huynh-Feldt and Bonferroni corrections, univariate tests showed that the main effect of mathematics was not statistically significant with $F(1.89, 657.83) = 1.48$, $p = .23$. The main effect for science, though, was statistically significant with $F(1.99, 691.50) = 81.62$, $p < .001$. Examination of the means revealed that grades decreased slightly from 6th to 8th grade in mathematics and increased overall in science. Simple planned contrasts for grade compared each subsequent year to the initial year of 6th grade in which teachers had no AMSTI training. In science, planned contrasts showed a significant increase between 6th grade science CRT scores (with no AMSTI implementation) and 7th grade CRT scores (with half a year AMSTI implementation), $F(1, 348) = 177.44$, $p < .001$, as well as a significant increase between 6th grade and 8th grade (with one year AMSTI implementation), $F(1, 348) = 45.10$, $p < .001$.

Multivariate tests with Roy's Largest Root indicated that a statistically significant interaction occurred between SES and grade, $F(4,345) = 4.76$, $p = .001$. Using Huynh-

Feldt and Bonferroni corrections, univariate tests showed that the main effect for both mathematics, $F(1.89, 657.83) = 7.43$, $p = .001$, and science, $F(1.99, 691.50) = 5.99$, $p = .003$, are significant. Simple planned contrasts for mathematics for the interaction of SES and grade showed significant differences between 6th grade mathematics CRT scores and 7th grade CRT scores, $F(1, 348) = 12.51$, $p < .001$, as well as a significant difference between 6th grade and 8th grade, $F(1, 348) = 7.48$, $p = .01$. Simple planned contrasts for science for the interaction of SES and grade also showed significant differences between 6th grade science CRT scores and 7th grade CRT scores, $F(1, 348) = 13.09$, $p < .001$, but not 6th grade and 8th grade, $F(1, 348) = 2.67$, $p = .10$.

Examination of the interaction graphs as well as the means (Table 32, Figure 3 and Figure 4) showed that the difference between the SES subgroups in both mathematics and science decreased sharply between 6th and 7th grade and then increased slightly between 7th and 8th. Between 6th and 7th grade, the mathematics CRT means of free/reduced lunch ineligible students dropped while eligible students' means increased resulting in a smaller difference. The opposite effect occurred between 7th and 8th grade. Science means showed that the same pattern occurred with the differences although the means spiked during the 7th grade.

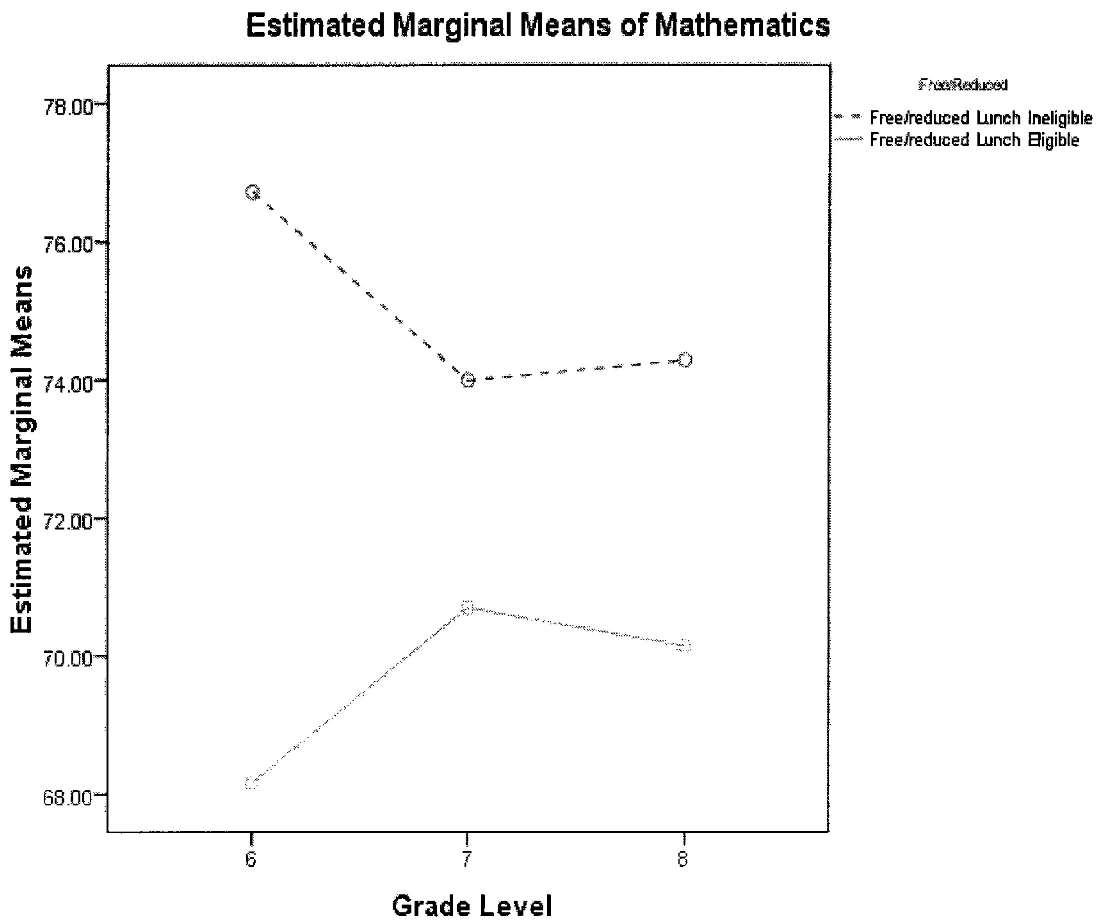

Figure 3. Interaction Graph for Grade v. Mathematics by SES.

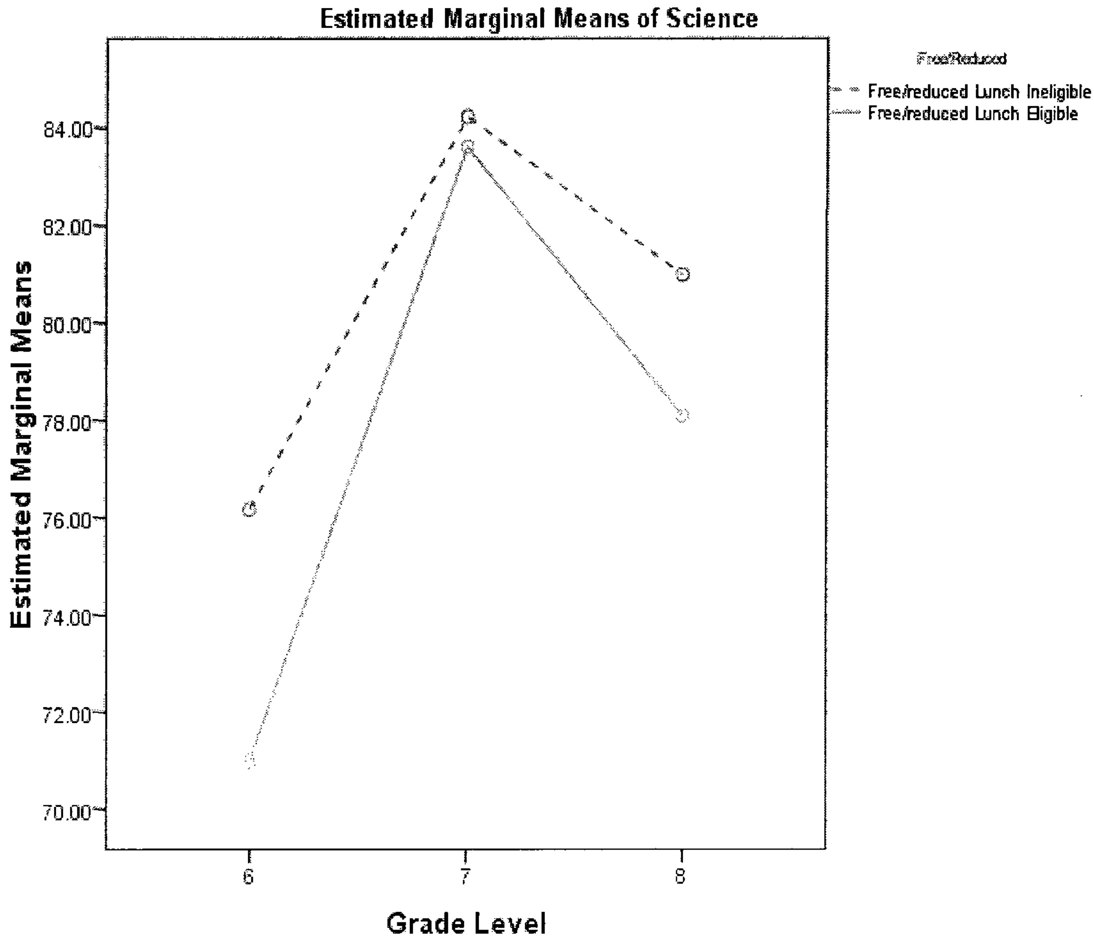

Figure 4. Interaction Graph for Grade v. Science by SES.

Table 32

CRT Estimated Marginal Means by SES and Grade Interaction

Subject	SES	Grade	Mean	Std. Error
Mathematics	Free/reduced lunch ineligible	6	76.72	1.06
		7	73.99	.88
		8	74.29	1.03
	Free/reduced lunch eligible	6	68.16	1.22
		7	70.70	1.02
		8	70.15	1.19
Science	Free/reduced lunch ineligible	6	76.18	.94
		7	84.23	.81
		8	80.99	.99
	Free/reduced lunch eligible	6	70.98	1.09
		7	83.61	.93
		8	72.10	1.14

Testing the between-subjects factor of SES, when controlling for gender, multivariate tests using Roy's Largest Root found that a statistical difference in SES with $F(2, 347) = 9.58$, $p < .001$. Using Bonferroni's correction, univariate test found the main effect of both mathematics and science to be significant with $F(1, 348) = 17.97$, $p < .001$ and $F(1, 348) = 6.13$, $p = .01$ respectively, with the difference between the CRT scores of SES subgroups decreasing although, in both subject areas, students ineligible for free/reduced lunch continued to score higher than eligible students each year.

A statistically significant decrease was discovered in the difference found in the CRT scores for mathematics and science between SES subgroups. The hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades, therefore, was supported.

Special/Regular Education

Examination of the estimated marginal means showed that regular education students consistently scored higher in both mathematics and science special education students (Table 33). The estimated marginal means for subject by grade level produced by the MANCOVA run with special/regular education classification as the IV (Table 34), in contrast to the descriptive statistics of the other three IVs, showed a slight increase in means throughout the three grades. Science means revealed the same pattern as previously discussed with the means increasing from 6th to 7th, and then decreasing in 8th grade (Table 34).

Table 33

CRT Estimated Marginal Means by Special/Regular Education Classification

Subject	Status	Mean	Std Error
Mathematics	Regular Ed	73.58	.64
	Special Ed	60.87	2.47
Science	Regular Ed	80.14	.57
	Special Ed	66.63	2.23

Note. N = 332 for Regular Education and 22 for Special Education.

Table 34

CRT Estimated Marginal Means for Special/Regular Education Classification and Grade

Subject	Grade	Mean	Std Error
Mathematics	6	64.55	1.64
	7	67.97	1.36
	8	69.15	1.61
Science	6	66.37	1.42
	7	80.25	1.23
	8	73.54	1.50

Note. N = 332 for Regular Education and 22 for Special Education.

A mixed design MANCOVA was used to address research question four: Does the application of AMSTI create a statistically significant difference in the mathematics and science scores achieved by students by special education versus regular education classification in 6th, 7th, and 8th grades? Gender was run as a covariate. Box's Test of Equality of Covariances, Levene's Test of Equality of Error, and Mauchly's Test of Sphericity were conducted to test for violations of assumptions. Box's Test of Equality of Covariances indicated that the assumption of homogeneity of covariances was met, $F(21, 4727.89) = 1.50, p = .07$.

In addition, Levene's Test of Equality of Error Variances indicated that the assumption of homogeneity of variances was not met for some of the grade levels with $F(1, 352) = 13.02, p < .001$ for 6th grade mathematics, $F(1, 352) = 4.59, p = .03$ for 7th grade mathematics, and $F(1, 352) = 15.20, p < .001$ for 6th grade science. The exceptions were 8th grade mathematics with $F(1, 352) = .76, p = .38$, 7th grade science with $F(1, 352) = .66$, $p = .42$, and 8th grade science with $F(1, 352) = 2.39$, $p = .12$ which met the assumption of homogeneity of variances. F_{max} tests were subsequently performed for those grade levels and subject areas that failed to meet the assumption of homogeneity of variance with Levene's test resulting in the means for 7th grade mathematics meeting the assumption of homogeneity of variances with $F_{max} = 1.87$. The means of 6th grade CRT mathematics and science scores, though, still did not meet the assumption of homogeneity of variance with $F_{max} = 2.3$ and $F_{max} = 2.53$, respectively.

Mauchly's Test of Sphericity indicated that the assumption of sphericity between the within groups was not met for mathematics, $W = .93$, $\chi2(2) = 25.52$, $p < .001$ or science, with $W = .98$, $\chi^2(2) = 6.74$, $p = .03$. The degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (€ = .94 for mathematics and € = .99 for science).

A mixed design MANCOVA was run using gender as the covariate. Multivariate tests using Roy's Largest Root found a statistically significant difference for the within-subjects grade, $F(4, 348) = 29.02$, $p < .001$. Using Huynh-Feldt and Bonferroni corrections, univariate tests showed that the main effect of mathematics was statistically significant with $F(1.89, 663.02) = 6.75$, $p = .002$. The main effect of science also was statistically significant with $F(1.99, 696.65) = 51.27$, $p < .001$. Examination of the means reveals that grades decreased slightly from 6th to 8th grade in mathematics and increased overall in science. Simple planned contrasts for grade compared each subsequent year to the initial year of 6th grade in which teachers had no AMSTI training. In mathematics, planned contrasts showed no significant difference between 6th grade science CRT scores (with no AMSTI implementation) and 7th grade CRT scores (with half a year AMSTI implementation), $F(1, 351) = 3.43$, $p = .07$. A significant difference was found between 6th grade mathematics and 8th grade (with one year AMSTI implementation),

$F(1, 351) = 11.23$, $p = .001$. In science, planned contrasts showed a significant difference between both 6th grade science CRT scores and 7th grade CRT scores, $F(1, 351) = 112.29$, $p < .001$, and between 6th grade and 8th grade, $F(1, 351) = 23.84$, $p < .001$. Examination of means showed increases in mathematics and science means.

Multivariate tests with Roy's Largest Root indicated that a statistically significant interaction occurred between Special/Regular education and grade, $F(4,348) = 4.63$, $p = .001$. Using Huynh-Feldt and Bonferroni corrections, univariate tests showed that the main effect of mathematics for the interaction was statistically significant with $F(1.89, 663.02) = 7.84$, $p = .001$. The main effect of science for the interaction was also found statistically significant with $F(1.99, 696.65) = 5.48$, $p = .004$. Simple planned contrasts for the interaction of Special/Regular Ed. and grade showed significant differences between 6th grade mathematics CRT scores and 7th grade CRT scores, $F(1, 351) = 7.93$, $p = .01$, as well as between 6th grade and 8th grade, $F(1, 351) = 11.95$, $p = .001$. Simple planned contrasts for the interaction of Special/Regular Ed. and grade also showed significant differences between 6th grade science CRT scores and 7th grade CRT scores, $F(1, 351) = 11.74$, $p = .001$, but not 6th grade and 8th grade, $F(1, 351) = 1.27$, $p = .26$.

Examination of the interaction graphs as well as the means (Table 35, Figure 5 and Figure 6) showed that special education mathematics means increased from 6th to 8th while regular education students' CRT means decreased slightly. In science, the difference between special/regular ed. means decreased between 6th and 7th grade and then increased between 7th and 8th, resulting in an overall decrease in the difference. Science means again displayed the same increase in 7th grade.

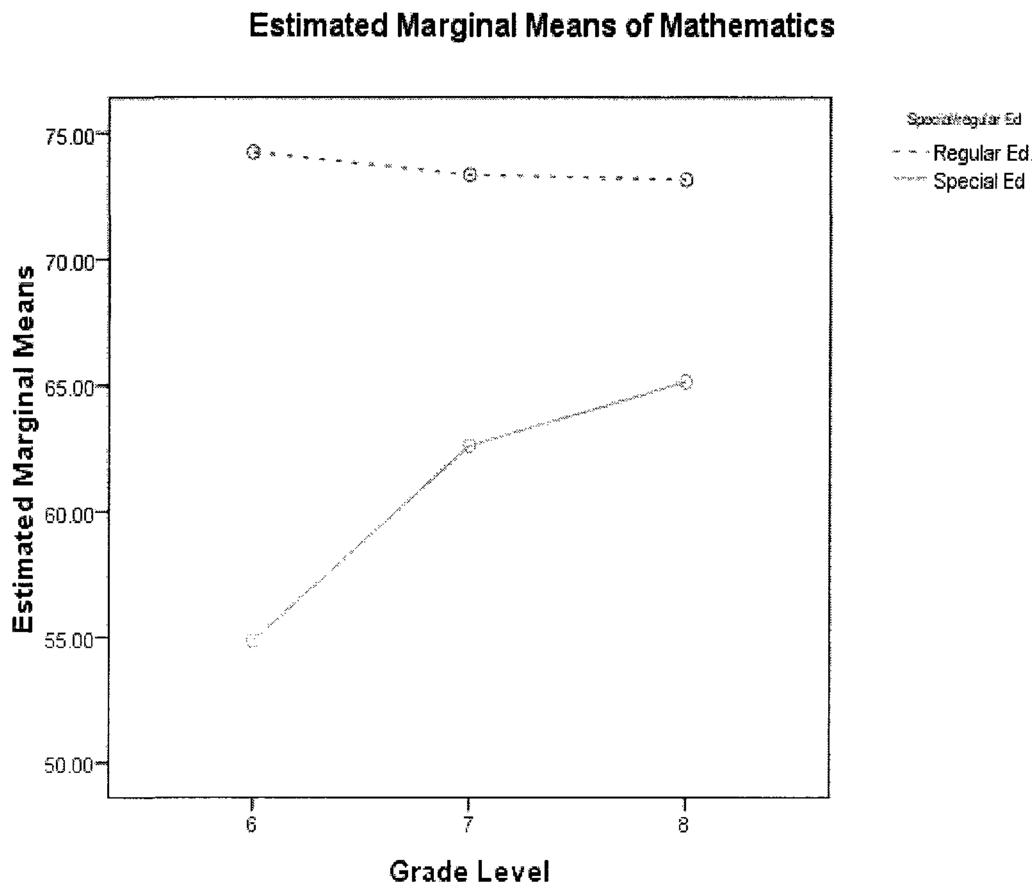

Figure 5. Interaction Graph for Grade v. Mathematics by Special/Regular Education Classification.

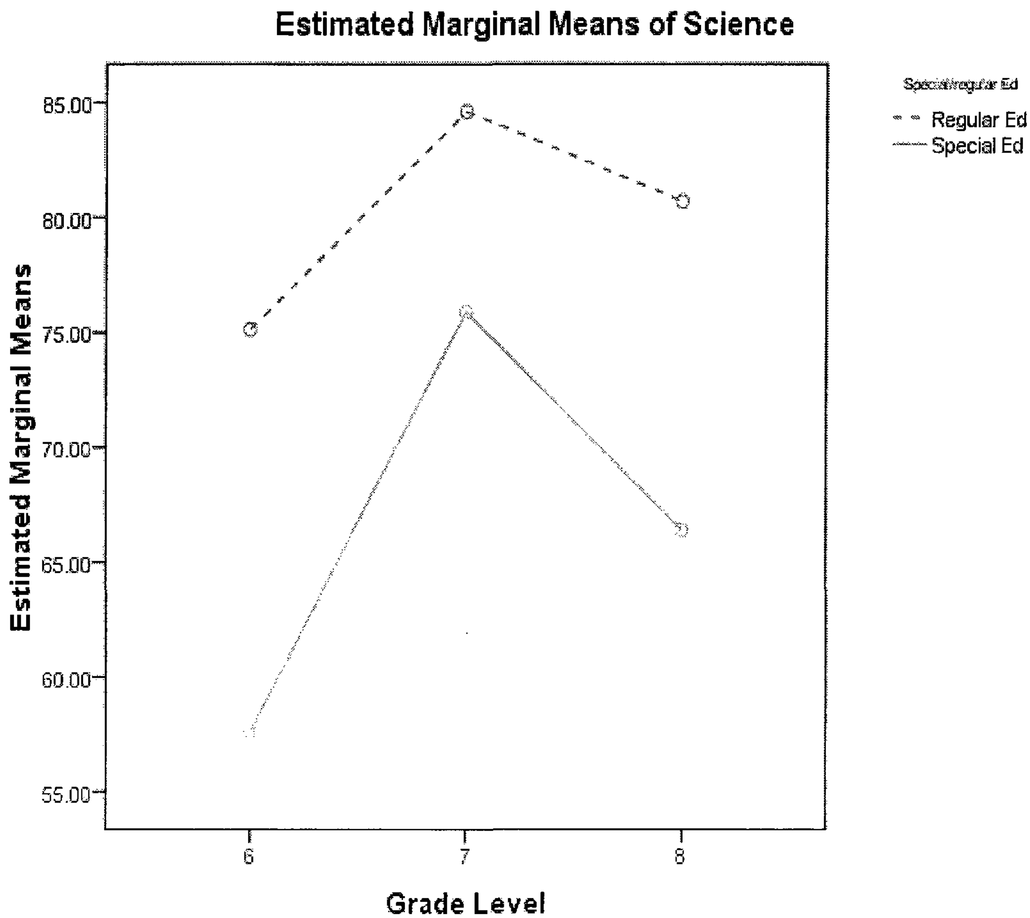

Figure 6. Interaction Graph for Grade v. Science by Special/Regular Education Classification.

Table 35

CRT Estimated Marginal Means by Special/Regular Education Classification

Classification and Grade Interaction

Subject	Special/Regular Ed.	Grade	Mean	Std. Error
Mathematics	Regular Education	6	74.24	.82
		7	73.34	.68
		8	73.15	.80
	Special Education	6	54.85	3.18
		7	62.60	2.63
		8	65.15	3.12
Science	Regular Education	6	75.13	.71
		7	84.60	.62
		8	80.69	.75
	Special Education	6	57.60	2.75
		7	75.90	2.39
		8	66.40	2.91

Testing the between-subjects factor of special/regular education, when controlling for gender, multivariate tests using Roy's Largest Root found that a statistically significant difference in special/regular education with $F(2, 350) = 17.59$, $p < .001$. Using the Bonferroni correction, univariate tests found the main effect of both mathematics and science to be significant with $F(1, 351) = 24.87$, $p < .001$ and $F(1, 351) = 34.38$, $p < .001$, respectively with the difference between the CRT scores of SES subgroups decreasing overall. Students classified as regular education, though, continued to score higher than special education students.

A statistically significant decrease was discovered in the difference in the CRT scores for mathematics and science found between the grades of special/regular education subgroups. The hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students in special education versus regular education classification in 6th, 7th, and 8th grades, therefore, was supported.

AMSTI Teacher Questionnaire

The AMSTI Teacher Questionnaire addressed the following research questions:

5. Do teachers report a significant increase in the number of inquiry-based lessons used in the classroom after being AMSTI trained?

6. Do teachers report a positive increase in their perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained?

This portion of the study included teachers from Schools A, B, C, and D. School A is the only school in this study that was used in both parts of the study. Table 36 shows that the schools were approximately equally represented in this portion of the study except for School D which was a much smaller school compared to the other participating schools. All schools had a higher than the expected return rate of completed survey instruments with an average return of almost 86%. As seen in Table 36, School A, which was also part of the CRT data collection part of this study, was the largest school to participate in the survey portion of this study but had the lowest return rate of 65%. School D, the smallest, had a 100% return rate.

Table 36

Survey Instrument Return Rates

	Schools			
	A	B	C	D
Student population	1421	759	1147	258
Number of Mathematics and Science Teachers	22	14	13	4
Number of Returned Completed Questionnaires	15	13	11	4
Percent of Returned Questionnaires	65	93	85	100

Table 37 shows that of the teachers returning the questionnaire, most received an average of 1.5 years of AMSTI training. Table 37 also indicates that almost one-third of the teachers surveyed had received no AMSTI training. Only a small portion, about 15%, of teachers received more than two years of training. Frequencies for the grade taught showed that 8th grade teachers were most represented as was the subject of science over mathematics. The average number of years of teaching was between 6 and 15 with almost 40% of the respondents indicating that they had 5 or fewer years of teaching experience. No teacher reported having 16 to 20 years of experience teaching. The mean indicated that the number of years of teaching in middle school as slightly less than the number of years of experience teaching school with almost 50% of teachers having fewer than 6 years experience. The number of years of science teaching experience was left blank in the SPSS data program for the mathematics teachers. The reverse was done for the science teachers. The mean for the number of years experience teaching mathematics was higher than the mean for teaching in middle schools indicating that many of these teachers had experience other than at middle schools in either high schools or elementary schools. One teacher reported having more than 20 years experience teaching mathematics. The respondents teaching middle school science had the least amount of teaching experience in science with an average of 6 – 10 years of experience. Only one teacher reported having more than 15 years experience, reporting more than 20 years of experience teaching science.

Table 37

AMSTI Teacher Demographics

	N	%	Mean	Standard Deviation
1. Number of years of AMSTI training.			1.47	1.12
0 year	10	23		
1 year	12	28		
2 years	14	33		
3years	5	12		
>3 years	2	5		
2. Grade predominately being taught.				
6	15	35		
7	11	26		
8	16	37		
Multiple grades	1	2		
3. Subject(s) being taught.				
Mathematics	24	56		
Science	16	37		
Mathematics and Science	3	7		

Table 37 (continued).

	N	%	Mean	Standard Deviation
4. Total number of years of experience teaching.			2.56	1.55
0 to 5	17	40		
6 to 10	5	12		
11 to 15	9	21		
16 to 20	4	9		
> 20	8	19		
5. Total number of years of experience teaching middle school.			1.91	1.17
0 to 5	21	49		
6 to 10	12	28		
11 to 15	6	14		
16 to 20	1	2		
> 20	3	7		
6. Total number of years teaching math.			2.15	1.23
0 to 5	12	28		
6 to 10	4	9		
11 to 15	7	16		
16 to 20	3	7		
> 20	1	2		
Missing	16	37		

Table 37 (continued).

	N	%	Mean	Standard Deviation
7. Total number of years teaching science.			1.56	1.10
0 to 5	13	30		
6 to 10	2	5		
11 to 15	2	5		
16 to 20	0	0		
> 20	1	2		
Missing	25	42		

Note. N = 43.
[a] Participants were coded missing. See text for explanation.

As indicated by responses to questions 8 – 24, most teachers responded that they believed inquiry-based lessons, critical-thinking skills, and student reflection are important to student learning (Table 38). Question 10 was reversed from the majority of the other questions in its construct and had the expected low mean. Questions 9 and 13 were stated negatively and the means were low indicating a relatively high use of the number of inquiry-based lessons used four years ago. Questions 17 and 21 dealt with teachers' use of inquiry-based lessons in the classroom this year and were stated reversed of each other. As expected, the mean for Question 17 was relatively high while the mean for Question 21 was relatively low.

Table 38

AMSTI Item Responses: Means and Standard Deviations

	Mean	Std. Deviation
8. Inquiry-based lessons are necessary to student learning.	4.00	.98
9. I never used inquiry-based lessons in my classes four years ago.	2.21	.98
10. Cooperative learning decreases student learning.	1.70	.67
11. In order to develop deeper understanding of subject content, students should reflect on their lessons.	4.23	.65
12. Inquiry-based lessons are effective at building critical thinking skills.	4.28	.59
13. I never used hands-on activities in my class four years ago.	1.83	.62
14. Students who work in cooperative learning groups develop deeper understanding of subject content.	4.09	.75
15. When students write explanations of lessons, the quantity and quality of their content knowledge increases.	4.14	.83
16. Inquiry-based lessons are effective at building problem solving skills.	4.28	.59
17. I use inquiry-based lessons often in my classes now. [a]	3.58	.98
18. Inquiry-based lessons build deeper understanding of concepts.	4.14	.57
19. Student peer groups strengthen student understanding.	4.02	.74
20. Students should record what they learn during a lesson to reinforce the learning.	4.05	.90

Table 38 (continued).

	Mean	Std. Deviation
21. I rarely use hands-on activities in my class now.	2.05	1.09
22. Students should be engaged in lessons that feature problems found in everyday life.	4.33	.52
23. Students' communicating what they have learned to others is important for the students' understanding of the lesson content.	4.21	.68
24. Use of journals increase students' understanding and retention of subject content.	3.93	.96

Note. Answers were placed on a Likert scale where 1= Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree.
[a] Question 17 was reverse coded.

To answer research question five: Do teachers report a significant increase in the number of inquiry-based lessons used in the classroom after being AMSTI trained? A dependent samples *t*-test was conducted on Questions 9, 13, 17, and 21. These questions did not form a construct, but were a group of questions designed to assess the frequency of inquiry-based lessons in the classroom. Questions 9 and 13 referred to use of inquiry-based lessons prior to AMSTI training (i.e., four years ago) while Questions 17 and 21 addressed current usage. Responses to Questions 9 and 13 were averaged to form a single variable. Question 17 was originally stated reversed of the other three questions in this group and therefore, was recoded to reflect the tone of Questions 9, 13 and 21. Question 17 was then averaged with Question 21 to form a separate variable.

A dependent *t*-test was used compare the means of the two newly formed variables so as to evaluate the data for significant differences in the reported use of inquiry-based lessons in the classroom between four years ago and current usage. The assumption of interval values was met because data were collected on a Likert scale. Examination of the histograms, though, indicated that the assumption of normality was violated. The data were not normally distributed which was expected because of the nature of the Likert scale. Although teachers reported a slightly higher use of inquiry-based lessons in the current year as compared to four years ago, no statistically significant difference was found between teachers' usage of inquiry-based lessons four years ago ($M = 2.02$, $SE = .110$) and in the current year ($M = 2.25$, $SE = .142$) and $t(41) = -1.697$, $p = .10$, $r = .26$. The effect size was .26 which is considered small.

The remaining questions were grouped into three constructs: effect of inquiry lessons, cooperative learning, and reflection. Reliability was analyzed using a Cronbach's alpha criteria of .70 or higher considered satisfactory. The first construct, the effect of inquiry lessons, included Questions 8, 12, 16, 18, and 22. It had a Cronbach's alpha of .83. The second construct, cooperative learning, consisted of Questions 10, 14, 19, and 23. Question 10 was originally stated reversed compared to the other questions on the questionnaire and therefore, was recoded. The Cronbach's alpha was .58. Question 23 was removed from the construct for this study and the reliability factor rose to .72. The third construct, reflection, included Questions 11, 15, 20, and 24. It had a Cronbach's alpha of .85.

To answer research question six: do teachers report a positive increase in their perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained, independent t-tests were run on each of the constructs using the number of years trained by AMSTI as the grouping factor. A cut point of one year was used to define the comparison groups. Ten teachers responded that they had received less than one year of

AMSTI training while 33 teachers reported having received one or more years of training. The assumption of interval values was met because data were collected on a Likert scale, as well as the assumption of independent scores. Examination of the histograms indicated that the assumption of normality was violated. The data were not normally distributed which was expected because of the nature of the Likert scale. The data for the first two constructs, effect of inquiry-based lessons and cooperative learning, met the assumption of homogeneity of variance with Levene's tests of $p = .131$ and .326 respectively. The third construct, student reflection, failed to meet the assumption with a Levene's test of $p = .036$.

No statistically significant difference was found for any construct between the groups of teachers with less than one year of AMSTI training and those who had one or more. With equal variances assumed, the belief in the efficacy of inquiry-based lessons for teachers with more than one year of training ($M = 4.30$, $SE = .093$) was higher, but not significantly so than for teachers with less than one year training ($M = 3.98$, $SE = .151$) and $t(41) = 1.696$, $p = .10$, $r = .26$. The effect size was .26 which is considered small. With equal variances assumed, the belief that cooperative learning is effective for teachers with more than one year of training ($M = 3.31$, $SE = .060$) was higher, but not significantly so, than for teachers with less than one year training ($M = 3.13$, $SE = .074$) and $t(41) = 1.546$, $p = .13$, $r = .23$. The effect size was .23 which is considered small. With equal variances not assumed, the belief that student reflection is important for teachers with more than one year of training ($M = 4.12$, $SE = .135$) was higher, but again not significantly so, than for teachers with less than one year training ($M = 4.00$, $SE =$

.118) and $t(32.433) = .676, p = .50, r = .12$. The effect size was .12 which is considered small.

The analysis of the questionnaire data set did not support either of this study's two hypotheses that the use of the AMSTI program significantly increased the number of inquiry-based lessons teachers report being used in the classroom after being AMSTI trained nor that the use of the AMSTI program significantly increased teachers' reported perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained.

The purpose of Chapter IV was to address the following research questions which were posed in Chapter I:

1. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades?
2. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by gender in 6th, 7th, and 8th grades?
3. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students by socioeconomic status in 6th, 7th, and 8th grades?
4. Does the application of AMSTI create a statistically significant difference, when $p \leq 0.05$, in the mathematics and science scores achieved by students in special education versus regular education classification in 6th, 7th, and 8th grades?

5. Do teachers report a significant increase in the number of inquiry-based lessons used in the classroom after being AMSTI trained?

6. Do teachers report a positive increase in their perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained?

After an in-depth review of the accepted literature and conducting analyses of the data, this study found the following results:

1. Even though a statistically significant decrease was found in the difference between the races, no meaningful effect could be attributed to either mathematics or science; therefore, the hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades was not accepted.

2. No statistically significant difference was found between the genders; therefore, the hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students of different races in 6th, 7th, and 8th grades was rejected.

3. A statistically significant decrease was discovered in the difference found in the CRT scores for mathematics and science between SES subgroups; therefore, the hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores

achieved by students of different races in 6th, 7th, and 8th grades was supported.

4. A statistically significant decrease was discovered in the difference in the CRT scores for mathematics and science found between the grades of special/regular education subgroups. The hypothesis that the implementation of the AMSTI program will significantly decrease differences in mathematics and science scores achieved by students in special education versus regular education classification in 6th, 7th, and 8th grades, therefore, was supported.

5. The analysis of the questionnaire data set did not support either of this study's two hypotheses that the use of the AMSTI program significantly increased the number of inquiry-based lessons teachers report being used in the classroom after being AMSTI trained nor that the use of the AMSTI program significantly increased teachers' reported perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained.

CHAPTER V

DISCUSSION AND CONCLUSION

Summary

The purpose of this study is to determine whether the application of the AMSTI program in middle schools decreased the differences in the mathematics and science CRT scores of students within the subgroups: race, gender, SES, and special/regular education students. Upon examination of mathematics and science scores, analyses found that CRT mean scores increased significantly between 6th and 8th grade. Unfortunately, the mathematics CRT means, expressly, were found to decrease slightly across the three years of this study. More specifically, the mathematics CRT scores decreased for each subgroup variable although only the special/regular education subgroups decreased significantly. Science CRT means, though, increased between the first and third year of this study. Specifically, the science CRT scores increased between 6th and 7th grade and subsequently decreased in 8th, although science scores remained significantly higher than scores in the 6th grade.

To directly answer the research questions, between-subject tests were conducted and significant differences were found between the subgroups in the variables of SES and special education. Upon closer inspection, significant decreases in differences were found in both the mathematics and science CRT scores in SES and special/regular education. A significant decrease in the gap between the races was found, but no meaningful effects were found in either mathematics or science. Gender was the only subgroup in which no significant change was found.

The AMSTI Teacher Questionnaire was used to determine if the reported use of AMSTI increased the number of inquiry-based lessons used in the classroom and if teachers' reported perceptions of the efficacy of the use of inquiry-based lessons after being AMSTI trained increased or became more positive. Examination of the survey instrument's data showed, based upon teachers' reported opinions, that using AMSTI in the classroom neither increased the use of inquiry-based lessons nor did it create a more positive attitude towards inquiry.

Discussion and Conclusion

Upon first glance, the data in this study echoed the disparity in the subgroups that was revealed by the NAEP data discussed in Chapter II. NAEP data revealed large gaps in the scores for 8th grade mathematics and science of the subgroups presented in this study (Grigg et al., 2005; Lee et al., 2007). NAEP found that whites, students ineligible for free/reduced lunch, and those classified as regular education outscored other races, students who were eligible for free/reduced lunch, and special education students. Similarly NAEP data reflected a gap between the genders although it was much smaller with the scores of males scoring just slightly higher than females. These same disparities between the subgroups were found in the participating schools except in gender where females scored higher than males in both mathematics and science.

In mathematics, national data showed increasing scores while maintaining the differences within the subgroups (Grigg et al., 2005). But, while NAEP data found national mathematics scores increasing, mathematics CRT scores in this study consistently decreased very slightly throughout the three years of this study. Also, while the NAEP data found consistent gaps between the subgroups, all the subgroups' scores rose. The differences in the subgroups' mathematics scores in this study, though, decreased slightly within SES and special/regular education subgroups, remained consistent between races, and increased between genders. NAEP also found males outscored females, but the opposite occurred in this study with females outscoring males.

Overall in this study, mathematics scores for whites, females, full pay lunch, and regular education students decreased during this period from 6th to 7th grade and then rose in the 8th grade, with the exception of regular education students, which continued to decline very slightly. At the same time, mathematics CRT scores of blacks, free/reduced lunch eligible students, and special education students rose while males' scores maintained status quo. An exception was special education which increased throughout the time frame for this study. The drop in the mathematics CRT scores of the higher scoring students with a concurrent rise in the lower scoring students' scores accounts for the decrease in the differences within the subgroups, even though there is not an overall increase in the mathematics scores. Gender showed a different pattern from 7th to 8th grade when males experienced a sharp decrease while females experienced a sharp increase in their scores.

Special education students were the only subgroup that could be considered successful because their mathematics scores continued to rise throughout the three years of this study even though regular education students' means declined throughout the three years of the study. The data support the hypotheses that application of AMSTI's mathematics program did decrease the differences in the subgroups, but this decrease occurred only through the drop in the higher student scores which resulted in an overall decrease in students' mathematics achievement.

It may appear that the findings in this study in the area of mathematics are not supported by the theories discussed in the literature review of Dewey, Piaget, and Vygotsky. Such theories suggested that more hands-on and reflective lessons lead to increases in student learning. To better understand the findings of this study and this apparent disconnect, the researcher discussed the findings of this study with the chair of the mathematics department and several mathematics teachers at one of the schools in this study. The following insights were shared. AMSTI trained teachers were issued a textbook during AMSTI training that was to be utilized in the classroom. Although the department chair stated that the text was a good resource and contained useful inquiry-based activities that focused on teaching skills consecutively, teachers may not have used it. CRTs administered by the school district in which this study took place were aligned with pacing guides. Mathematics teachers were issued pacing guides each year that outlined which objectives were to be taught each day. According to the department chair, the text did not fit the pacing guides and teachers were pressured to adhere to the pacing guides. This expectation made it difficult to deviate from the pacing guides and left little opportunity to use the AMSTI textbook.

Another possible explanation for the slight decrease in mathematics CRT scores may be the slump that occurs in academic achievement during the middle school years (Loveless & Diperna, 2000). Specifically, student mathematics scores in the United States in both the NAEP and TIMSS (Trends in International Mathematics and Science Study) data were found to decrease starting sometime after the fourth grade. This decrease continued through the twelfth grade. The lack of achievement has been blamed on: the lack of student motivation because standardized tests such as Stanford, TIMSS, and NAEP do not have the same accountability for students as school-based tests, lower dropout rates retain lower achieving students, and tracking prevents students from being exposed to higher level mathematics classes thereby perpetuating lower achievement (Loveless & Diperna, 2000).

Another confounding factor may have been that, according to several mathematics teachers, the internal validity of the mathematics CRTs was suspect. Many teachers complained that the tests did not accurately reflect the curricular objectives that the pacing guides specified. This possibility must be considered since the mathematics means of almost all subgroups decreased slightly across the years of this study in direct contrast to NAEP and published AMSTI data. It is possible that a different assessment instrument, such as the Stanford-10, may have yielded different results.

Science scores revealed a much different pattern from both the mathematics scores and the NAEP science data. NAEP data showed that science scores nationally were stagnant with little to no change in the differences within the subgroups (Lee et al., 2007). However, data from this present study showed significant increases in science CRT means in general throughout the three years of this study, as well as a significant decease in the differences found between all subgroups except gender. Between the 6th and 7th grades, students in all subgroups made statistically significant gains with the lower scoring student subgroups (blacks, females, free/reduced lunch eligible students, and special education students) making the greatest gains. In addition, the differences between the scores in all of the subgroups between the 6th and 7th grades decreased. Although no significant change was found in the difference between genders, this study found that females, who scored lower in 6th grade, outscored the males in the 7th and 8th grades. Between 7th and 8th grade though, all students' science scores decreased, but remained higher than scores found in 6th grade. In addition, the difference between the subgroups' science scores during this time increased except in gender where the difference decreased.

The data collected in this study does not provide evidence of why the gaps narrowed and then expanded. Examination of the Alabama State Courses of Studies showed that the subject matter was different each year in science from the 6th to the 8th grade (ASDE, 2009c). The 6th grade consisted of Earth and Space, 7th grade of Life, and 8th of Physical Science. Some of the inconsistencies may be explained by the different levels of difficulty of the subject content and students' varying areas of interests. The data, though, seems to support the theories of Dewey, Piaget, and Vygotsky just as it supported the hypothesis that the more the AMSTI kits were utilized the higher the science CRT scores would be.

AMSTI kits may not have been closely aligned with science objects for each grade level. An AMSTI science specialist, whose identity must remain anonymous, indicated that AMSTI material covered most of the 7th grade science objectives. Textbooks could be used to augment the kits. In the 8th grade however, fewer of the objectives were covered by the AMSTI kits; therefore, the kits were used to augment the textbooks. Data showed science scores were lowest in the 6th grade, spiked in the 7th grade, and although higher than the 6th grade, decreased in the 8th. Scores were lowest when no AMSTI science kits were used in the 6th grade, highest when AMSTI was most closely aligned in the 7th, and between the 6th and 7th grade means when AMSTI kits were partially used in the 8th. Data showed that science means increased with possible increased use of the AMSTI kits and decreased when the AMSTI material was least closely aligned; this could possibly support the theories of Dewey, Piaget, and Vygotsky that inquiry-based learning increases understanding.

The AMSTI Teacher Questionnaire showed no change reported by teachers, from four years ago until the present, in the number of inquiry-based lessons or in the teachers' attitudes toward inquiry learning. Teachers reported that they believed inquiry was a productive form of instruction and that they used inquiry-based lessons frequently in the classroom before, as well as after AMSTI training. Since teachers had to volunteer to participate in AMSTI, it is reasonable to assume that many of these teachers already valued and already were implementing some aspects of inquiry-based learning before becoming AMSTI trained. The survey also relied on self-reported data based upon reported beliefs in what the teachers were doing at the time of this study and also on what they remembered about their own personal teaching techniques four years ago. Human memory can be fragile and impressionable (NRC, 2000b). Teachers reported what they remembered and the memories could have been influenced by the techniques and information encountered during the four years covered by the questionnaire. It is also possible, even with anonymity assured, that some of the teachers felt pressure to answer that they believed in inquiry and had been using it, even if this was not their true beliefs. They may have felt that to do otherwise was to imply that they were not good teachers.

Limitations

This study operated under the following limitations:

1. The data may have been limited as a result of a natural disaster. The landfall of Hurricane Katrina prevented CRTs from being administered

one quarter, and most likely affected at least another quarter's scores. Hurricane Katrina was a traumatic event that disrupted the lives of many students living in the South. However, the timeframe selected for this study yielded the fewest possible confounding factors.

2. Another limitation was that the researcher had no control over teacher test preparation for the CRTs. As revealed through interviews with a test coordinator, whose identity must remain confidential, teachers varied as to how closely they taught to the test versus review of subject matter. Variations existed in the quantity of time used as well the type of review techniques. CRT study guides were issued each year by the central office. Each teacher received the same study guide, specific for the upcoming quarter test, at the same time each quarter. Some teachers began immediately to review while others waited. Interviews with department chairs, whose identities again must remain confidential, revealed that, in mathematics, study guides were composed of example problems and questions that were similar to the test questions while, in science, study guides were comprised of the stems of all test questions in the test bank as well as the correct answers. Test banks were amended each year but changes were minimal. As a result, at least in science as confirmed by the school district science supervisor, some teachers had previous study guides and used them throughout the quarter in their teaching. In spite of the limitations, the CRTs were the only comparable assessments available to measure mathematics and science across grade levels and schools.

3. A further limitation involved the lack of control or documentation to determine the extent to which the teachers involved in this study used the AMSTI materials. As confirmed by AMSTI, all teachers did not equally use the provided AMSTI material so it was impossible to state unequivocally how much of the effects on the CRT mathematics and science scores seen in this study were caused by the addition of the AMSTI program to the classroom. Also, no attempt was made in this study to track or document additional techniques and materials that were added to the classroom by the teachers. The researcher considered reviewing lesson plans to document AMSTI use; however, examination of lesson plans, at best, would have been faulty because some teachers do not use lesson plans while others write generic ones that cover only the essentials required by the school system. Lesson plans also are, by definition, what and how teachers plan to teach on a specific day, not necessarily what they in reality do. AMSTI, itself, does not monitor teacher usage other than to check the kits when they are returned to determine their condition.

4. One limitation inherent in the AMSTI Teacher Questionnaire was self-reporting. Teachers were asked to self-report on their practices and attitudes. Even though the questionnaire was anonymous, teachers may have felt influenced to answer the questions in a certain manner. Because of a phenomenon called the social desirability response set, the respondents may have scored the survey in a more positive tone, seeking

to appear as a better and possibly more acceptable teacher (Di Iorio, 2005). No attempt was made to verify teachers' self-reported data so information obtained from the survey instrument was only as accurate as the teachers' responses.

5. Another limitation of the study was that other programs, specifically mathematics programs created by the emphasis placed upon the success of lower scoring students by NCLB may have impacted the CRT scores (USDE, 2004). These programs may have included tutoring as well as increased inclusion of special education students in the regular classroom; these changes may be a possible explanation for the decrease in the means of higher scoring student subgroups and the rise in the means of the lower scoring subgroups. During the time of the study, other programs were ongoing simultaneously with the AMSTI program. These programs were inclusive of but not limited to: tutoring, remediation classes, and mentoring. Some of these programs began before AMSTI was introduced into the schools while some began during AMSTI implementation. Some of these programs overlapped each other as students participated in multiple programs. Such programs could have impacted student performance on CRTs and this study.

6. This study was limited by sample size. The populations of the subgroups for minorities and special education students were very small. The schools chosen for the assessment instrument were selected because they had the fewest confounding factors, such as beginning and ending the AMSTI

training at the same time. Unfortunately, this decision resulted in small populations of blacks, Hispanic American, Native American, and special education students. Therefore, the results of this study may not be generalized to schools with large populations of these subgroups.

7. Another limiting factor was the internal validity of the mathematics CRTs. Based upon the fact that the mathematics data in this study showed trends different than those found in the NAEP and AMSTI data, as well as the insights offered by the mathematics teachers, it is possible that the internal validity was low.

8. Another possible limitation was that special education CRT scores were not applied to the special education students' classroom grades unless the CRT scores would not lower the students' grades; this restriction did not apply to regular education students and CRT scores were applied to their grades regardless of the results. Special education students' knowledge that low CRT scores would not lower their quarter grades, regardless of the score, may have affected some of the students' motivation to succeed.

Recommendations for Future Studies

An interesting study would be to compare the mathematics and science scores of students with AMSTI trained teachers to those who do not have AMSTI trained teachers at the student level. This study revealed many interesting aspects of AMSTI, but at the same time, generated many questions. The results of this study appear to conflict with studies that reported significant improvements in student achievement in schools where the AMSTI program had been implemented (AMSTI, 2008). To resolve the apparent disparity, a student-level study similar to the one conducted in this paper needs to be done which includes a comparison of the achievements of non-AMTI taught students.

Studies also should further investigate the subgroups of race and special education. The number of participants in this study was too small to draw definitive conclusions that can be generalized to other populations. Additionally, similar studies using national or state standardized exams with no study guide distributed prior to testing would provide more curriculum-driven data rather than assessment-driven data. Using standardized national or state level tests, instead of school district generated tests such as the CRT, would reduce the variable of differentiated preparation times and practices for the test, eliminate the chance of the internal in-house security being breached, and ensure internal validity.

Further studies need to be conducted specifically on the mathematics achievement. This study only showed that no improvements were seen in the means. Unfortunately, too many variables affected this study that could not be controlled. The major confounding factor was a possible lack of internal validity of the mathematics CRTs. If in fact the mathematics CRTs lack validity, then the results of this study for mathematics would also be invalid. Since literature shows that other independent studies of AMSTI have confirmed that both of their mathematics and science programs produced significant increases in scores, the participating school system should research conducted on the validity of their CRTs, especially mathematics.

Of interest would be studies of teachers' instructional styles. Surveys should be conducted pre- and post-AMSTI implementation. In addition to teacher survey instruments, documentation of the number of inquiry-based lessons needs to be conducted over a period of several weeks, possibly a quarter, before AMSTI is implemented. The same process should be used the last year of AMSTI implementation. It is important to know if the AMSTI training is causing teachers to use more inquiry-based lessons. If it is not, then AMSTI should adjust the time invested in training or adjust the training itself.

Recommendations for Practice

Unfortunately, the mathematics data showed no clear results. But, based upon the fact that the gaps between some of the subgroups were found to decrease significantly, it is recommended that the mathematics portion of AMSTI be retained. Before extending AMSTI into other schools in the school district, it is recommended, though, with mathematics CRT means decreasing throughout the three years of this study that a thorough examination is made of all programs being utilized at each school. It is possible that differing programs are conflicting with each other. If more than one program is in place in the classroom then it is reasonable to conjecture that the programs may adversely affect each other, resulting in decreased student scores.

Based upon the results of this study, a recommendation is made that the science portion of AMSTI be continued in AMSTI-participating schools and expanded to schools that do not yet have AMSTI. Evidence was found to suggest that AMSTI raises science CRT scores. Enough evidence was also found to support the claim that AMSTI reduces the gaps found in the science CRT means between several subgroups.

Another suggestion for the science program in this school district is based upon that fact that AMSTI science kits were used in other parts of the state of Alabama (AMTI, 2008). Based upon an interview with an AMSTI science specialist, it is believed that the science kits for 7th grade meet the Alabama State Course of Studies and fit into the school district's pacing guides. Since the 7th grade CRT means were highest for all the years examined and the only year in which AMSTI was fully utilized, a further recommendation is for the school district to align 6th and 8th grade pacing guides and CRTs with AMSTI kits.

Even though the mathematics data did not support the hypotheses that AMSTI reduces the disparities present in the subgroups, the science data has provided enough evidence to support three of the four hypotheses proposed in this study. The results from the data were strong enough to justify further research. This study supports the premise that AMSTI not only improved grades at the student level, specifically science, but that it has the potential, if it is effectively applied to decrease the differences that exist between various subgroups.

APPENDIX A

PERMISSION FROM PILOT SCHOOL'S PRINCIPAL

Middle School

Phone:
Fax:

Principal
Assistant Principal
Assistant Principal
Assistant Princip

January 15, 2009

Mrs. Toni Ramcy, eighth grade Science teacher at Middle School, has asked for and received permission to conduct a study at our school. This will consist of a survey instrument that will be distributed to the faculty for the purpose of conducting a pilot test on the questionnaire.

Thank you,

Principal

APPENDIX B

IRB APPROVAL OF PILOT TESTING

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

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Hattiesburg, MS 39406-0001
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HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **29030301**
PROJECT TITLE: **Alabama Mathematics Science and Technology Initiative (AMSTI) Teacher Questionnaire Pilot**
PROPOSED PROJECT DATES: **01/30/09 to 12/30/09**
PROJECT TYPE: **New Project**
PRINCIPAL INVESTIGATORS: **Toni Ramey**
COLLEGE/DIVISION: **College of Education & Psychology**
DEPARTMENT: **Educational Leadership & Research**
FUNDING AGENCY: **N/A**
HSPRC COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **03/03/09 to 03/02/10**

Lawrence A. Hosman (signature) — 3-06-09

Lawrence A. Hosman, Ph.D. — Date
HSPRC Chair

APPENDIX C

PILOT SURVEY INSTRUMENT

AMSTI Teacher Questionnaire

Instructions: Thank you for participating in this study of the impact of AMSTI on teachers' beliefs. This questionnaire is voluntary and you may withdraw at any time. Respondents' identities will remain confidential. Your participation in this survey is appreciated though. It has been designed to minimize the time needed to complete it. Simply circle the response that most accurately reflects your answer.

1. I work at

2. Grade predominately taught.	6	7	8			
3. Subject taught.	math	science				
4. Total number of years of experience teaching.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	NA
5. Total number of years of experience teaching middle school.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	NA
6. Total number of years teaching math.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	NA
7. Total number of years teaching science.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	NA

8. Inquiry lessons are necessary to student learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
9. I never used inquiry lessons in my classes four years ago.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
10. Cooperative learning decreases student learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
11. In order to develop deeper understanding of subject content, students should reflect on their lessons.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
12. Inquiry lessons are effective at building critical thinking skills.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
13. I never used hands-on activities in my class four years ago.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
14. Students who work in cooperative learning groups develop deeper understanding of subject content.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

15. When students write explanations of lessons, the quantity and quality of their content knowledge increases.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
16. Inquiry lessons are effective at building problem solving skills.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
17. I use inquiry lessons often in my classes now.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
18. Inquiry lessons build deeper understanding of concepts.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
19. Student peer groups strengthen student understanding.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
20. Students should record what they learn during a lesson to reinforce the learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
21. I rarely use hands-on activities in my class now.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
22. Students should be engaged in authentic lessons.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
23. Students' communicating what they have learned to others is important for the students' retention of the lesson content.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
24. Use of notebooks/journals increase students' understanding and retention of subject content.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

APPENDIX D

PERMISSION TO CONDUCT STUDY BY SUPERINTENDENT

BOARD OF SCHOOL COMMISSIONERS
President – District 1
V. President – District 5
Ph. D. – District 2
Ph D. – District 3
– District 4

Public School System

Alabama SUPERINTENDENT Ed.D

February 17, 2009

Toni Ramey

Dear Ms Ramey,

Please accept this letter as my consent and approval for you to conduct a study on the impact of AMSTI on student scores in mathematics and science in the subgroups of race, gender, socio-economic status, and special education. The anonymity of students, school, and school system will be observed throughout the study and is guaranteed and the final results will be shared with the Public School System

Thank you for your interest in our students I look forward to the findings of your study

Sincerely,

Superintendent

RN/cp

APPENDIX E

PERMISSION TO CONDUCT STUDY BY HUMAN SUBJECTS REVIEW COMMITTEE

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

118 College Drive #5147
Hattiesburg, MS 39406-0001
Tel: 601.266.6820
Fax: 601.266.5509
www.usm.edu/irb

HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **29050505**
PROJECT TITLE: **The Impact of the Alabama, Mathematics, and Technology Initiative (AMSTI) on Middle School Students' Scores in Mathematics and Science by Race, Gender, SES, and Special Education**
PROPOSED PROJECT DATES: **01/30/09 to 12/30/09**
PROJECT TYPE: **Dissertation or Thesis**
PRINCIPAL INVESTIGATORS: **Toni Ramey**
COLLEGE/DIVISION: **College of Education & Psychology**
DEPARTMENT: **Educational Leadership & Research**
FUNDING AGENCY: **N/A**
HSPRC COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **05/11/09 to 05/10/10**

Lawrence A. Hosman
Lawrence A. Hosman, Ph.D.
HSPRC Chair

5-15-09
Date

APPENDIX F

COVER LETTER FOR SURVEY INSTRUMENT

Dear Teacher:

I am a science teacher at and am in the process of conducting a study that examines the effect of AMSTI on various subgroups of students in mathematics and science as well as the affect on teachers' instructional styles and beliefs. The attached questionnaire examines the effects of AMSTI on teachers' instructional styles and beliefs. I know your time is precious and apologize for adding to your duties but I will greatly appreciate it if you would take about 10 minutes to complete this questionnaire. The results of this study can lead to a better understanding of the affects of AMSTI on student achievement. You were identified to participate in this study because you were AMSTI trained. Your participation is voluntary and your individual responses will remain anonymous and confidential. Once the study is completed, all questionnaires will be destroyed and only composite data will be reported. If you choose not to participate, you may return a blank questionnaire with no reprisals.

The results of this study will be shared with the central office, AMSTI, and the Alabama State Department of Education, which works closely with AMSTI. It is possible that the analysis of the results of your responses will be included in a future publication. The names of individual teachers, individual schools nor the school district will be identified. By participating in this study, you will help us better understand the possible benefits of AMSTI. This in turn, hopefully, will benefit you in meeting the needs of students.

By completing and returning the attached questionnaire you are granting permission for this anonymous and confidential data to be used for the purposes described in this letter. If you have any questions concerning this questionnaire research project, please feel free to contact me. Thank you for helping me with this research.

Sincerely,
Toni Ramey

This project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research subject should be directed to the chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-001, (601) 266-6820.

APPENDIX G

AMSTI TEACHER QUESTIONNAIRE

AMSTI Teacher Questionnaire

Instructions: Thank you for participating in this study of the impact of AMSTI on teachers' beliefs. This questionnaire is voluntary and you may withdraw at any time. Respondents' identities will remain confidential. Your participation in this survey is appreciated though. It has been designed to minimize the time needed to complete it. Simply circle the response that most accurately reflects your answer.

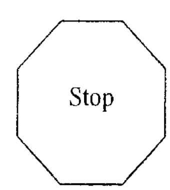
1	Number of years of AMSTI training received at this time.	0 years	1 year	2 years	3 years	> 3 years	
2	Grade predominately being taught at this time.	6	7	8			
3	Subject(s) being taught at this time.	math	science				
4	Total number of years of experience teaching.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	
5	Total number of years of experience teaching middle school.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	
6	Total number of years teaching math.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	NA
7	Total number of years teaching science.	0 to 5	6 to 10	11 to 15	16 to 20	> 20	NA
8	Inquiry-based lessons are necessary to student learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
9	I **never** used inquiry-based lessons in my classes four years ago.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
10	Cooperative learning **decreases** student learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	

Continued on next page.

11	In order to develop deeper understanding of subject content, students should reflect on their lessons.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
12	Inquiry-based lessons are effective at building critical thinking skills.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
13	I **never** used hands-on activities in my class four years ago.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
14	Students who work in cooperative learning groups develop deeper understanding of subject content.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
15	When students write explanations of lessons, the quantity and quality of their content knowledge increases.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
16	Inquiry-based lessons are effective at building problem solving skills.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
17	I use inquiry-based lessons **often** in my classes now.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
18	Inquiry-based lessons build deeper understanding of concepts.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
19	Student peer groups strengthen student understanding.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
20	Students should record what they learn during a lesson to reinforce the learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Continued on next page.

20	Students should record what they learn during a lesson to reinforce the learning.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
21	I **rarely** use hands-on activities in my class now.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
22	Students should be engaged in lessons that feature problems found in everyday life.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
23	Students' communicating what they have learned to others is important for the students' understanding of the lesson content.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
24	Use of journals **increase** students' understanding of subject content..	Strongly disagree	Disagree	Neutral	Agree	Strongly agree



REFERENCES

Aiken, W. M. (1942). *The story of the eight-year study.* New York: Harper.

Alabama Mathematics, Science, and Technology Initiative (AMSTI) Committee. (2000, October). *Report on the review of literature.* Paper presented to the State Board of Education, Montgomery, AL.

Alabama Mathematics, Science, and Technology Initiative (AMSTI). (2008). Retrieved December 30, 2008, from http://www.amsti.org/index.html

Alabama State Department of Education. (2009a). *Public data reports* [Data file]. Available from Alabama State Department of Education Web site, http://www.alsde.edu/PublicDataReports/Default.aspx

Alabama State Department of Education. (2009b). *Special education publications -- statistical information* [Data file]. Available from Alabama State Department of Education Web site, ftp://ftp.alsde.edu/documents/65/EDSERPR24.pdf

Alabama State Department of Education. (2009c). *Course of study* [Data file]. Available from Alabama State Department of Education Web site, http://www.alsde.edu/html/search_results.asp?menu=search&footer=general

Alexander, K., & Alexander, M. D. (2005). *American public school law.* Belmont, CA: Thomson West.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). (2001). *Atlas of science literacy.* Washington, DC: Author.

Baker, D., & Leary, R. (2003). Letting girls speak out about science. *Journal of Research in Science Teaching, 40* (Suppl.), S176-S200.

Baker, K., & Mack, A. (1998). *Bayer/NSF Award seeks middle school students with big ideas.* Retrieved December 29, 2008, from http://www.christophercolumbusawards.com/news/pr19980903.htm

Brainerd, C. J. (1978). *Piaget's theory of intelligence.* Englewood Cliffs, NJ: Prentice-Hall.

Byrnes, J. P. (2001). *Minds, brains, and learning.* New York: Guildford Press.

Calvin, W. H., & Ojemann, G. A. (1980). *Inside the brain: Mapping the cortex, exploring the neuron.* Los Angeles: New American Library.

Campbell, R. L. (2006). *Jean Piaget's genetic epistemology: Appreciation and critique.* Retrieved November 11, 2008, from http://hubcap.clemson.edu/~campber/piaget.html

Clark, J. (1999). *Minorities in science and mathematics.* Retrieved December 25, 2008, from http://www.ericdigests.org/2000-2/minorities.htm

Cogan, L. S., & Schmidt, W. H. (1999). *What we've Learned from the TIMSS middle school mathematics reform.* Retrieved February 19, 2007, from http://U.S.timss.msu.edu/midmathematicsreform.html

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education.* New York: Macmillan.

Dewey, J. (1939). *Intelligence in the modern world: John Dewey's philosophy.* (J. Ratner, Ed.). New York: The Modern Library.

Dewey, J. (1998). *Experience and education.* West Lafayette, IA: Kappa Delta Pi (Original work published in 1938).

Dewey, J. (2004). *How we think.* Whitefish, MT: Kessinger (Original work published in 1933).

Di Iorio, C. K. (2005). *Measurement in health behavior.* San Francisco, CA: Wiley.

EduTrax: Strategic decision support tools. (2009). Retrieved July 8, 2009, from http://www.edutrax.us/et-home.asp

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). London: Sage.

Fraenkel, J. R., & Wallen, N. E. (1996). *How to design and evaluate research in education.* New York: McGraw-Hill.

Framm, M. S., Miller-Cobb, J. E., & Van Horn, L. (2007). Poverty, race, and the contexts of achievement: Examining educational experiences of children in the U.S. South. *Social Work, 52,* 309-319.

Galloway, C. M. (2001). *Vygotsky's constructionism. In M. Orey (Ed.), Emerging perspectives on learning, teaching, amd technology.* Retrieved November 15, 2008, from University of Georgia Web site: http://projects.coe.uga.edu/epltt

Gooding, J., & Metz, B. (2008). A blueprint for cultivating inquiry. *Science Scope, 32*(1), 12-14.

Gresalfi, M. Martin, T., Hand, V., & Greeno, J. (2008). Constructing competence: An analysis of student participation in the activity systems of mathematics classrooms. *Educational Studies in Mathematics, 70*(1), 49-70.

Grigg, W., Laulo, M., & Brockway, D. (2005). *The nation's report card: Science 2005* (NCES 2006-466). Washington, DC: U.S. Government Publishing Office.

Hansen, D. (2002). Dewey's conception of an environment for teaching and learning. *Curriculum Inquiry, 32*(3), 267-280.

Harris, R., & Burke, K. (2008). Developing the essential features of inquiry. *Science Scope, 32*(1), 40-46.

Hassard, J. (2000). *7.4 Inquiry models of teaching.* Retrieved June 21, 2003, from Georgia State University Web site: http://scied.gsu.edu/Hassard/mos/7.4.html

Jayaratne, T. E., Thomas, N. G., & Trautmann, M. (2003). Intervention program to keep girls in the science pipeline: Outcome differences by ethnic status. *Journal of Research in Science Teaching, 40*, 393-411.

Jennings, J. J. (1997). School reform based on what is taught and learned. In D. L. Flinders & S. J. Thornton (Eds.), *The curriculum studies reader* (pp. 266-273). New York: Routledge.

Jensen, E. (1998). *Teaching with the brain in mind.* Alexandria, VA: Association for Supervision and Curriculum Development.

Joyce, B., Weil, M., & Calhoun, E. (2000). *Models of teaching.* Boston: Allyn and Bacon.

Kahle, J. B., & Damnjanovic, A. (1997). *How research helps address gender equity.* Retrieved February 23, 2007, from http://www.narst.org/publications/research/gender2.cfm

Layman, J. W., Ochoa, G., & Heikkinen, H. (1996). *Inquiry and learning.* New York: College Entrance Examination Board.

Lee, J., Grigg, W. S., & Dion, G. S. (2007). *The nation's report card: Mathematics 2007* (NCES 2007494). Washington, DC: U.S. Government Publishing Office.

Lee, J., & Wong, K. K. (2004). The impact of accountability on racial and socioeconomic equity: Considering both school resources and achievement outcomes. *American Educational Research Journal, 41*, 797-832.

Lightell, K. (2001). *Bayer/NSF award winners use science and technology to address Native American housing shortage and provide low-cost energy source to impoverished communities.* Retrieved February 14, 2009, from http://www.christophercolumbusawards.com/news/2001/0001winners.htm

Lindsay, J. (2002). What the data really shows: Direct instruction really works. Retrieved December 29, 2008, from http://www.jefflindsay.com/EducData.shtml

Llewellyn, D. (2002). *Inquire within.* Thousand Oaks, CA: Corwin Press.

Loveless, T., & Diperna, P. (2000). *How well are American students learning?* Washington, DC: The Brown Center Report on American Education.

Lucks, R. (1999). *Constructivist teaching vs direct instruction.* Retrieved December 29, 2008, from University of Delaware Web site: http://ematusov.soe.udel.edu/final.paper.pub/_pwfsfp/0000017b.htm

Ma, X. (2000). Socioeconomic gaps in academic achievement within schools: Are they consistent across subject areas? *Educational Research and Evaluation, 6*, 337-355.

Marsh, C. J., & Willis, G. (2003). *Curriculum: Alternative approaches, ongoing issues.* Columbus, OH: Prentice Hall.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

McAllister, B. A., & Plourde, L. A. (2008). Enrichment curriculum: Essential for mathematically gifted students. *Education, 129*(1), 40-49.

McKim, B. (2007). The road less traveled. *Phi Delta Kappan, 89*, 298-299.

National Education Association (NEA). (1895). *Report of the committee of fifteen on elementary education with the reports of the sub-committees: on the training of teachers; on the correlation of studies in elementary education; on the organization of city school systems.* New York: American Book.

National Research Council (NRC). (1996). *National science education standards.* Washington, DC: National Academy Press.

National Research Council (NRC). (2000a). *National science education standards.* Washington, DC: National Academy Press.

National Research Council (NRC). (2000b). *How people learn.* Washington, DC: National Academy Press.

National Science Foundation (NSF). (1992). *Decade of achievement: Educational Leadership in Mathematics, Science and Engineering* (Publication No. NSF9294). Retrieved April 7, 2009, from http://www.nsf.gov/pubs/stis1992/nsf9294/nsf9294.txt

North Central Regional Educational Laboratory. (n.d.a). *Critical thinking skills.* Retrieved December 21, 2008, from http://www.ncrel.org/sdrs/areas/issues/envrnmnt/drugfree/sa3crit.htm

North Central Regional Educational Laboratory. (n.d.b). *Problem-solving skills.* Retrieved December 21, 2008, from http://www.ncrel.org/sdrs/areas/issues/students/atrisk/at6lk7.htm

North Central Regional Educational Laboratory. (n.d.c). *Thinking skills.* Retrieved December 21, 2008, from http://www.ncrel.org/sdrs/areas/issues/students/atrisk/at6lk4.htm

Obama, B. (2009, Feb 24). *Remarks of President Barack Obama - Address to Joint Session of Congress.* Retrieved February 25, 2009, from http://www.whitehouse.gov/the_press_office/Remarks-of-President-Barack-Obama-Address-to-Joint-Session-of-Congress/

Pegg, J. M. (2006). *Developing explanations: Students reasoning an out science concepts during claims-evidence inquiry lessons.* Oregon State University, United States – Oregon. Retrieved February 23, 2009, from Dissertations & Theses: Full Text database. (Publication No. AAT 3241576).

Piaget, J. (1955). *The construction of reality in the child.* (M. Cook, Trans.). New York: basic Books.

Piaget, J. (1968). *Genetic epistemology.* (E. Duckworth, Trans.). New York: Columbia University Press.

Piaget, J. (1971). *Psychology and epistemology.* (A. Rosin, Trans.). New York: Grossman.

Piaget, J. (1972). *The principles of epistemology.* (W. Mays, Trans.). New York: Basic Books.

Piaget, J. (1975). *The development of thought.* (A. Rosin, Trans.) New York: Viking.

Piaget, J. (1977). *The essential Piaget.* (H. E. Gruber & J. J. Vonèche, Eds.) New York: Basic Books.

Rodgers, C. (2002). Defining reflection: Another look at John Dewey and reflective thinking. *Teachers College Record, 104*(4), 842.

Rogers, M. (2007). Action and inquiry in Dewey's philosophy. *Transactions of the Charles S. Peirce Society, 43*(1), 90-115.

Shin, N., & McGee, S. (2002). *The influence of inquiry-based multimedia learning environment on scientific problem-solving skills among ninth-grade students across gender differences.* Paper presented at the 2002 Association for Educational Communications and Technology. Retrieved October 12, 2003, from http://www.cet.edu/research/conference.html

Styron, R. A., Roberson, T., Schweinle, W., & Lee, D. E. (2005). I'm fighting a lion with a toothpick: The No Child Left Behind Act from the perspective of K-12 principals. *The Researcher, 19*(1), 27-31.

The Leadership and Learning Center. (2009). 90/90/90 study. Retrieved June 24, 2009, from http://www.leadandlearn.com/90-90-90

Tryphon, A., & Vonèche, J. (Eds.). (1996). *Piaget - Vygotsky: The social genesis of thought.* London: Psychology Press.

Tudge, J. (1990). Vygotsky, the zone of proximal development and peer collaboration: Implications for classroom practice. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 155-174). New York: Cambridge University Press.

U.S. Department of Education. (1983). *A nation at risk: The imperative for educational reform.* Retrieved February 15, 2009, from http://www.ed.gov/pubs/NatAtRisk/index.html

U.S. Department of Education. (1994). *Goals 2000: Educate America Act.* Retrieved February 15, 2009, from http://www.ed.gov/legislation/GOALS2000/TheAct/index.html

U.S. Department of Education. (1996). *Study of curriculum reform.* Retrieved December 29, 2008, from http://www.ed.gov/pubs/SER/CurricReform

U.S. Department of Education. (2002). *National Assessment of Educational Progress Authorization Act* (P.L. 107–279). Washington, DC: GPO.

U.S. Department of Education. (2004). *No child left behind; A toolkit for teachers.* Retrieved January 8, 2007, from http://www.ed.gov/teachers/nclbguide/nclb-teachers-toolkit.pdf

U.S. Department of Education. (2008). Highlights from trends in international mathematics and science study (TIMSS). Retrieved December 29, 2008, from http://nces.ed.gov/timss

U.S. Department of Education. (2009). *National Assessment Governing Board.* Retrieved February 23, 2009, from http://www.nagb.org/flash.htm

U.S. Department of Education Institute of Education Sciences. (2008). *National Center for Educational Statistics.* Retrieved December 21, 2008, from http://nces.ed.gov

University of Memphis. (2009). Quaid [computer software]. Retrieved March 30, 2009, from http://avalanche.psyc.memphis.edu/QUAID/login.aspx

Valverde, G. A., & Schmidt, W. H. (2006). *Refocusing U.S. mathematics and science education. Issues in science and technology.* Retrieved February 19, 2007, from http://www.issues.org/14.2/schmid.htm

Van't Hooft, M. (2005). The effect of the "Ohio schools going solar" project on student perceptions of the quality of learning in middle school science. *Journal of Research on Technology in Education 27*, 221-243.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* (M. Cole, Trans.). Cambridge, MA: Harvard University.

Vygotsky, L. S. (1987a). *The collected works of L. S. Vygotsky.* (Vol. 1). (R. W. Reiber & A.S. Carton, Eds.). (N. Minick, Trans.). New York: Plenum.

Vygotsky, L. S. (1987b). *The collected works of L. S. Vygotsky.* (Vol. 5). (R. W. Reiber & A.S. Carton, Eds.). (N. Minick, Trans.). New York: Plenum.

Vygotsky, L. S. (2004). Imagination and creativity in childhood. (M. E. Sharpe, Trans.). *Journal of Russian and East European Psychology, 42*(1), 7-97.

Weinburgh, M. H. (1994). *Achievement, grade level, and gender as predictors of student attitudes toward science.* Paper presented at the Distinguished Paper Session of the annual meeting of the American Association of Educational Research. Retrieved December 29, 2008, from http://www.ed.psu.edu/CI/Journals/1998AETS/s5_1_weinburgh.rtf

Wheeler, G. F. (2006/2007). Strategies for science education reform. *Educational Leadership, 64*(4), 30-34.

Willis, J. (2007). Teachable moments build relational memories. *Record, 43*(3), 106-109.