The Effectiveness of Mathematics and Science Partnership (MSP) Grants on Student Achievement

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The Effectiveness of Mathematics and Science Partnership (MSP) Grants on Student Achievement

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Abstract

Michael R. Schlabra. THE EFFECTIVENESS OF MATHEMATICS AND SCIENCE PARTNERSHIP (MSP) GRANTS ON STUDENT ACHIEVEMENT. (Under the direction of Dr. Karen Parker) School of Education, Liberty University, October, 2009.

The purpose of this study was to examine whether a Title II Mathematics and Partnership grant positively affected student achievement levels for 3rd grade students in a public school system. The primary participant populations for this study were third grade students enrolled in 4 elementary schools in north Georgia from 2005-2008. Over 4,500 student assessments were used to conduct the statistical research and variables such as gender, race, and socio-economic levels were not disaggregated in the data collection. The data sources included the first quarter, second quarter, and third quarter post formative assessments which were administered every nine-week grading period in the school system. Findings indicate that there is a significant change in the scores between quarters in all three years of the study. The data indicates that in the final year of the study, student achievement slipped to below baseline results in mathematics and equal to baseline results in science.

Dedication

I would like to dedicate this dissertation to my Lord and Savior Jesus Christ. His grace and mercy is sufficient to meet all of my needs.

Acknowledgements

I want to thank my wife Dr. Lisa Schlabra for her encouragement and support. I would not have attempted doctoral studies or this dissertation without her love and dedication. Many years of undergraduate and graduate studies preceded this dissertation, most at night, and to that end, I request forgiveness from my three daughters for a father who often was at class long after they had gone to sleep and missed tucking them in.

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Chapter 1

Introduction

Mathematics and Science education have been controversial content areas in public education for five decades. The space-race highlighted American public school deficiencies in these content areas and the need for improvement in teacher training, pedagogy, and student assessment. This quantitative study evaluated the effectiveness of a mathematics and science grant designed to increase teacher content knowledge and student achievement in one county school system in North Georgia. The first chapter of this study presents the background for the study, it specifies and amplifies the guiding question along with discussing the professional significance of the study, and finally, it defines several key terms and acronyms used in the research analysis.

Background of the Study

In 1957, the Soviet Union successfully launched Sputnik into the Earth's orbit. It is common knowledge that this act served as the catalyst for America's space-race with the Soviet Union and in turn, would promote the proliferation of nuclear arsenals. However, something else arose from the space-race. Americans had a collective feeling that the United States should be the global leader in technological advances. This was only affirmed as the United States completed successful lunar landings and later developed a space shuttle program that allowed the construction of a space station orbiting the Earth. For educators, Sputnik also launched something few educators ever see during their careers—a government edict supported by fiscal resources. At the time of Sputnik, the Democratic Senate Majority Leader Lyndon Johnson took his dismay for

Dwight Eisenhower's apathy towards Sputnik and when drafting his *Great Society* legislation, he ensured that technology and education would forever be conjoined with federal financial resources through the creation of Title II.

Lyndon Johnson's *Education and Secondary Education Act of 1965,* later reauthorized several times to become our *No Child Left Behind Act*, still supports and promotes the intent of Johnson and America's quest for technological prominence. The Title II program has developed two parts that pertain to education, technology, mathematics, and science. Title II originally focused upon mathematics and science content and curricula but it has been transformed, under *No Child Left Behind*, to include the regulations for teacher qualifications and certifications (U.S. Department of Education, 2008). Title II Part A primarily is concerned with teacher quality, so Part B was implemented to address mathematics and science needs. Title II Part D became known as the *Enhancing Education Through Technology Act of 2001* (U.S. Department of Education, 2008).

According to No Child Left Behind, public schools that receive federal funds must make yearly AMO (Annual Measureable Objective) goals in order to be deemed a school that makes AYP (Adequate Yearly Progress). The instructional process now is directly tied to funding, and a new social construct has been manufactured in education, vis-à-vis test scores, drive all decisions. In essence, quantifiable student achievement data has now taken the forefront in the planning, implementation, and development of district mission statements, visions, and belief statements. Achievement data is the driving force behind school improvement plans, teacher recruitment and retention, district financial plans, and a myriad of innovations and professional development programs designed to boost scores. In northwest Georgia, three school districts have formed a consortium that has been awarded Title II Part B funds. This grant is designed to bolster teacher content knowledge in mathematics and science, enable a seamless integration of the two curricula, improve standardized test scores in mathematics and science, and in turn, enable a school to make adequate yearly progress in mathematics and science.

Problem Statement

The researcher posed the following hypothesis that guided the study, the collection of data, and the conclusions and generalizations drawn: Teacher participation in the Title II math and science partnership (MSP) grant has a positive impact on mathematics and science student achievement levels.

The research questions and null hypotheses for this study involve three years of formative assessment data for twenty 3rd grade teachers. Three 9-week pre and post formative assessments in mathematics and science were analyzed for each year addressed.

Research Question 1 (RQ1a-f) explored if there was a statistically significant difference in change scores among the three 9-week grading periods in math and science for each year studied. Research Question 2 (RQ2a-f) also sought to determine if a statistically significant difference in change scores existed between 9-week grading periods by year. Finally, Research Question 3 (RQ3a-b) focused upon the differences among the average gain across years 1, 2, and 3 of the study. The hypotheses for Research Question 1 (RQ1a-f) are for math and science, in Year 1, 2, and 3, there are statistically significant differences in the change scores among the three nine-week grading periods. The hypotheses for Research Question 2 (RQ2a-f) are for math and science, there are statistically significant differences in the first, second, and third nine-week change scores among years 1, 2, and 3. Finally, the hypotheses for Research Question 3 (RQ3a-b) are for math and science, there are statistically significant differences among the average gains across years 1, 2, and 3.

Professional Significance

In January of 2002, the No Child Left Behind Act of 2001 (NCLB) became law. Title II Part B of this Act authorizes a Mathematics and Science Partnership (MSP) competitive grant program. The intent of this program is to encourage institutions of higher education (IHEs) and high-need local education agencies (LEAs) to participate in programs that increase the subject matter knowledge and teaching skills of teachers to improve the academic achievement of students in areas of mathematics and science. The MSP program supports partnerships between high-need K-12 school organizations and departments of engineering, mathematics and science in institutions of higher education, and other stakeholders. The MSP Program activities must be sustained, intensive, classroom-focused, and aligned with the Georgia Performance Standards. There must be a demonstrable and measurable improvement in both teacher content knowledge and, ultimately, student academic achievement in mathematics and/or science.

The Georgia Mathematics and Science Partnership (MSP) program strives to improve teacher quality through partnerships between state education agencies, institutions of higher education, high-need local education agencies, and schools to increase the academic achievement of students in mathematics and science. Other partners may include public charter schools, businesses, and nonprofit or for-profit organizations that have demonstrated effectiveness in improving the quality of mathematics and science teachers (Georgia Department of Education, 2009).

The MSP program is a formula grant program for the states, with the size of individual state awards based on student population and poverty rates. With these funds, Georgia is responsible for administering a competition in which grants are made to partnerships to improve the content knowledge and teaching skills of third through 12th grade mathematics and science teachers (Georgia Department of Education, 2009). This program supports the partnerships of at least one Georgia high-need school district or consortium, at least one institution of higher education department of science, mathematics, and/or engineering, and at least one institution of higher education's department of teacher preparation. The funding is used to provide professional learning for mathematics and science teachers.

Neither testing students nor developing teacher content knowledge is a standalone answer to raising student achievement levels. Sound assessment represents one essential key to school effectiveness. If standardized tests are understood by their intended users, or if classroom assessments are of high quality, then sound instructional decisions may be made on the basis of the data such tests generate, and student achievement may increase. However, if standardized tests are misunderstood or poorly used or if classroom assessments are of poor quality, then poor decisions may be made on the basis of the test-generated data, instruction may be ineffective, and students may suffer (Stiggins, 2005). The problem is that because generations of teachers and administrators lack assessment training, educators cannot assure their stake holders that standardized tests are being effectively used or that teachers are accurately assessing the achievement of their students.

Principals have two crucial responsibilities regarding assessment literacy. First, they must become assessment literate themselves. Without this basis of professional expertise, principals will remain unable to bring the issue of effective assessment to the forefront as a school priority or provide the support teachers need to develop and use assessments effectively in their classrooms. Second, principals must remove all barriers to the development of teachers' assessment literacy. These include personal, institutional, and community barriers (Ingersoll, 1999). Personal barriers may include the anxiety that accompanies trying new assessments before one is certain that they will work. The principal needs to assure teachers that initial failure to assess dependably or to use assessment effectively will not lead to a directive to stop trying. Institutional barriers may include a lack of time to learn and to experiment with new assessment ideas. Teachers need to know that school resources will be allocated for these purposes, and the principal needs to make sure that they are. Community barriers may include parents who question changes in assessment and communication procedures. Principals need to be assessment literate to be able to ease community concerns and to support teachers in their relationships with parents during the process of change (Ingersoll, 1999). Leadership is needed to create an instructional environment that expects and supports competence in assessment, as well as the effective application of that competence in the service of students' academic achievement.

Researcher William Sanders and his colleagues (Sanders & Horn, 1994; Wright, Horn, & Sanders, 1997) have noted that the individual classroom teacher has even more of an effect on student achievement than originally thought. As a result of analyzing the achievement scores of more than 100,000 students across hundreds of schools, their conclusion was:

> The result of this study will document that the most important factor affecting student learning is the teacher. In addition, the results show wide variation in effectiveness among teachers. The immediate and clear implication of this finding is that seemingly more can be done to improve education by improving the effectiveness of teachers than by any other single factor. Effective teachers appear to be effective with students of all achievement levels, regardless of the level of heterogeneity in their classrooms. If the teacher is ineffective, students under the teacher's tutelage will show inadequate progress academically regardless of how similar or different they are regarding their academic achievement (Wright et al., 1997).

Teacher quality emerges as a key component in student achievement. The quality of a teacher's training, along with the shift to a standards-based curriculum emphasizing a needs-based pedagogy highlights why teacher professional learning is paramount when predicting success in student achievement results.

Definition of Key Terms

To ensure clarity throughout the study, the following terms and acronyms are defined to assist the reader:

AMO Annual Measureable Objective – To determine Adequate Yearly Progress (AYP), these objectives are percentages of mastery that students must obtain in content areas.

AYP Adequate Yearly Progress – Under the *No Child Left Behind Act*, LEAs must meet and exceed AMOs in various content areas and in other secondary indicators in order to be labeled as a school or system that is progressing adequately.

CRCT	Criterion-Referenced Competency Test – Georgia's standardized test for 1^{st} through 8^{th} grade students.
LEA	Local Education Agency – Typically, this refers to a school system or district.
MSP	Mathematics and Science Partnership – The acronym for the grant awarded under Title II B.

Chapter 2

Literature Review

Introduction

This chapter is devoted to a review of literature explores the integration of math and science into the curriculum. The researcher seeks to investigate the effects of content specific professional learning to the achievement of students. This review of literature shall be divided into four parts: (1) the theoretical background of the topic; (2) its historical background; (3) related research conducted with regard to the integration of math and science as well as the effects of the said integration to student achievement; and finally, (4) the summary of all main points enumerated in this chapter. The divisions of this chapter shall reflect the main issues that are related to the research; these are the following: (1) math and science content integration; (2) professional training in math and science; and finally, the impact of both on student achievement.

Content integration, according to Czerniak and her colleagues (1999) has become acceptable and popular amongst the educators in recent years. These authors claim that the integration is valid for it seems like common sense. In the real world, as they note, the lives of the people are not actually separated into subjects as what is observed inside the four walls of the classroom. It is because of this then that calls for the integration of subjects within the academe is in the mainstream (Czerniak, et al., 1999; Daniels & Bizar, 2005). Aside from this, Raizen and Britton (1997) has also noted that the separate way of teaching mathematics and science has been proven ineffective for a large number of students who will eventually become an important part of the workforce. As a result, national reform efforts place the aforementioned at the center of their movements. They are stressing that there is a need to integrate or make connections among the curriculum (Black & Atkin, 1996; Hodson, 1986).

Aside from what has been discussed, Czerniak and her colleagues (1999) further stated that the integration of the curriculum is very important in creating schools that prioritizes the needs and interests of their students. Furthermore, these authors have also believed that this integration would also help the students in thinking critically while developing a knowledge that may be applicable in the next centuries. Through this, researchers cited by Czerniak et al., (1999) have all found that curriculum integration would enable students to see the so-called big picture by helping them understand concepts in a deeper sense. As a result, the curriculum is made more relevant to the students, making the latter more interested and motivated while inside the four walls of the classroom (Czerniak, et al., 1999; Pannabecker, 2002; Wicklein & Schell, 1995; Black & Atkin, 1996).

Theoretical Background

This section of the literature review shall cover the theoretical underpinnings of the topic at hand. In order to be more effective, three subtopics shall be explored; these are, namely: (1) math and science content integration; (2) professional training in math and science; and lastly, (3) the impact of content integration on the achievements of the students.

Math and Science Content Integration

The issue with regard to the integration of the mathematics and science subjects had a fairly long history, Rodriguez and Kitchen (2005) discuss. According to them, this is because of many reasons, of which the close relationship between the two subjects to the physical world is the most common (Rodriguez & Kitchen, 2005). Aside from this however, other reasons behind the need to integrate science and math were also seen to be relatively popular. One of which is the ability of science to provide students with concrete examples of mathematical ideas that are often times abstract (Rodriguez & Kitchen, 2005; Pang, 2000; Pannabecker, 2002; Mecca, 1991; Hewson & Hewson, 1984). On the other hand, mathematics can help students in understanding science concepts. Moreover, it was also seen that the use of scientific activities in order to illustrate important mathematical concepts have increased the relevancy of the said subject, thus increasing the motivation of the students to learn (Rodriguez & Kitchen, 2005; Mecca, 1991). In the succeeding parts of this chapter, this last reason shall often times be mentioned as a ground by which the claim for integration of the two subjects was strengthened.

Czerniak and her colleagues (1999) introduced the concept of math and science content integration through their review of previous literature also written with regard to the topic. They found out that concept of integration has been defined quite differently by authors and researchers who have delved in the examination of the said issue. One of the definitions of math and science integration presented in the study concerned the fusion of mathematical methods in science and scientific methods in mathematics. In this sense then, the two subjects – mathematics and science- seem quite indistinguishable (Czerniak, et al., 1999; Pannabecker, 2002; Haigh & Rehfeld, 1995).

However, the authors also recognize another existing yet different view of integration. According to the second definition they presented, the integration of math and science still entails the fusion of two concepts. However, only the theme serves as the unifying factor. This then means that while connections are made in order to integrate the two subjects, they remain recognizable as separate disciplines, thereby revealing the concept of an interdisciplinary approach (Czerniak, et al., 1999; Mecca, 1991; Venville, et al., 1998; Greeno & Goldman, 1998).

Davison, Miller and Metheny (1995), on the other hand, presented a more concise view of math and science integration. The authors identified the following as the five types of mathematics and science integration: (1) discipline-specific; (2) content specific; (3) process integration; (4) methodological integration; and lastly, (5) thematic integration. These kinds of integration show that mathematics and science are taught for their own sake. Nonetheless, they remain in close association with each other (Davison, Miller & Metheny, 1995; Czerniak, et al., 1999; Pang, 2000; Davison, 1995; Greeno & Goldman, 1998; Merrill, 2001; Cobbs & Nicol, 1998).

Watanabe and Huntley (1998, in Czerniak, 1999), identified the following as the major benefits that students may receive upon the proper integration of mathematics and science concepts: (1) the connections between the two subjects would provide students with tangible examples of mathematical ideas that are most of the time, abstract; (2) math helps the students gain a better understanding of relationships in the scientific field; and lastly, (3) the connections between the two assures the students that what they are learning in school is relevant, thereby increasing their motivation.

In the same manner, Furner and Kumar (2007) also acknowledged the different benefits that the students may receive once they receive an education using an integrated curriculum. According to these authors, this type of curriculum provides the students with more opportunities as it has the tendency to incorporate lessons that are more relevant, less fragmented, and stimulates more experiences for learners.

With regard to how mathematics and science can be properly integrated with one another, Furner and Kumar (2007), based on the studies of White and Berlin (1992) and Sunal and Furner (1995) have enumerated a set of recommendations and issues to be considered. These are the following: (1) to base the integration on how the learners experience, organize and perceive the two subjects – science and math; (2) to take advantage of patterns by which children try to make sense of the world; (3) to collect and use data that would integrate problem-based activities and the invocation of process skills; (4) consider the different areas where the contents of mathematics and science overlap; (5) for teachers to become sensitive to what their students believe and feel about the two subjects as well as the manner by which the former involves themselves and their abilities to do problems regarding math and science; and lastly, (6) to make use of instructional strategies in order to ensure the students that their classroom experiences are significantly related with their lives outside the four walls of the classroom.

Also, Furner and Kumar (2007) enumerated other issues that educators should consider in integrating the content of both mathematics and science. According to these authors, the teachers must think of ways by which the two subjects can be entirely related with each other. For instance, math could be treated as a language and tool by which scientific concepts could be taught or science as a very important aspect of math (Furner & Kumar, 2007; Flores, et al., 2002; Boaler, 1993).

It is in this respect then that Furner and Kumar (2007) has acknowledged the importance of problem-based learning in the integration of contents related to both mathematics and science. It is through the application of this kind of learning that the successful integration of the two will be achieved. In the same manner, the aforementioned also allows both the students and the teachers to understand the important role that mathematics play in understanding the different scientific concepts. As a result, the success of the students can be guaranteed for the said integration could help them to better understand what they are doing, thus becoming more motivated (Furner & Kumar, 2007; Roth, 1993). The following phrases summarize the different reasons behind the need to integrate the contents of both science and mathematics as discussed by the paper of Pang and Good (2000):

1. Mathematics and science are similar attempts to discover patterns and relationships.
2. Mathematics and science are based on interdependent ways of knowing.
3. Mathematics and science share similar scientific processes such as inquiry and problem solving
4. Mathematics and science should be connected to real life situations so that students learn and appreciate how different subjects are used together to solve an authentic problem.
5. Mathematics and science fundamentally require quantitative reasoning.

Major Theoretical Models of Integration

The succeeding paragraphs of this section shall explore different theories and models that had been developed by former researchers that seek to explain the integration of mathematical and scientific concepts.

According to Berlin and White (n.d.) most theoretical models developed concerning the integration of mathematics and scientific disciplines only focused on the interaction between the two subjects. Pang and Good (2000) note that this continuum deals mainly on the manner by which both disciplines are integrated with one another. The following definitions summarize the major theoretical models followed by a more detailed description:

Theoretical Model posited by the participants of the Cambridge Conference on Integration of Mathematics and Science Education (1967)- identified five categories wherein the disciplines of mathematics and science interact: (1) math for math; (2) math for science; (3) math and science; (4) science for math; (5) science for science.

Brown and Wall (1976)- fashioned the categories mentioned into a continuum that consist of the following: (1) mathematics for the sake of mathematics; (2) mathematics for the sake of science; (3) mathematics and science in concert; (4) science for the sake of mathematics; (5) science for the sake of science.

Lonning and DeFranco (1997)- described a continuum of mathematics and science by identifying the following dimensions: (1) independent mathematics; (2) mathematics focus; (3) balanced mathematics and science; (4) science focus; and (5) independent science.

Huntley (1998) - Explains the continuum by using a foreground/background analogy with the following categories: (1) mathematics for the sake of mathematics; (2) mathematics with science; (3) mathematics and science; (4) science with mathematics; and (5) science for the sake of science.

Roebuck and Warden (1998) – modified the continuum developed by Brown and Wall. Their model includes the following categories: (1) math for math's sake; (2) science-driven math; (3) mathematics and science in concert; (4) math-driven science; and (5) science for science's sake.

Hurley (2001) – determined five types of integration: (1) sequenced; (2) parallel; (3) partial; (4) enhanced; and (5) total.

Berlin-White Integrated Science and Mathematics Model (BWISM) – describes the center of the continuum, mathematics and science.

Theoretical Model Posited by the Participants of the Cambridge Conference on Integration of Mathematics and Science Education (1967)

The theoretical model proposed by the participants of the Cambridge Conference on the Integration of Mathematics and Science Education has identified five categories of interaction between science and mathematics by placing in on a linear curriculum (Berlin, n.d; Berlin & White, n.d.). These categories had been described as the following: first, math for math; second, math for science; third, math and science; fourth, science for math; and last, science for science. This description shows that both ends of the continuum have perceived both mathematics and science as separate entities. In this part of the curriculum, Berlin (n.d.) discusses that the beauty and abstractness of mathematics is explored without applying or using scientific concepts. In the same manner, the scientific phenomena are also investigated without the need for quantification (Berlin, n.d.; Flores, et al., 2002).

The next categories in the continuum are math for science and science for math, denoted by the acronyms Ms and Sm respectively. According to this model, the first is the category wherein mathematics is utilized in the context of the scientific discipline in order to guarantee the students' better understanding of the former (Berlin n.d.). In the same manner, the latter entails the focus on science through the use of mathematical tools in order to quantify the relationships and patterns existing in the said field (Berlin, n.d.). Finally, it is only in the middle category, Math and Science (MS) that the two disciplines completely integrate with each other, thus becoming one unified subject.

M	Ms	MS	Sm	S
Math	Math - Science Context	Math and Science	Science- Apply Math	Science

Figure 1. Mathematics and Science Integration Continuum (Cambridge Conference on Integration of Mathematics and Science Education, 1967, in Berlin, n.d.)

Brown and Wall (1976)

The theoretical model developed by Brown and Wall (1976) with regard to the integration of the mathematical and scientific disciplines completely adhered to the continuum developed by the participants of the Cambridge Conference on the Integration of Mathematics and Science Education. Researchers such as Abell and Lederman (2007); Berlin (n.d.) and Berlin and White (n.d.) note that the said framework features mathematics and science still at both ends of the continuum. This then denotes that the two subjects are taught separately. In the same manner, next to the aforementioned are two categories: mathematics guided by science and science guided by mathematics. Just like the theoretical model discussed above, these show the fusion of two concepts in order to gain a better understanding of both disciplines. Finally, the last category, concurring with the theoretical model produced by the Cambridge Conference, has shown the union between mathematics and science (Abell & Lederman, 2007).

Lonning and DeFranco (1997)

The continuum developed by Lonning and DeFranco (1997), according Abell and Lederman (2007), begins with what must be done first in planning for an integrated curriculum. According to them, educators must first ask: what are the major mathematics and science concepts being taught in the activity? In the same manner, curriculum planners must also first look into which of these concepts are important and which should be eliminated once they are found to be redundant or unnecessary (Lederman & Niess, 1998; Lonning & DeFranco, 1997; Knapp, 1997).

Similar to the other theoretical models discussed, the continuum developed by Lonning and DeFranco, according to Abell and Lederman (2007) has looked into the different categories by which the mathematical and scientific disciplines interact with each other. In the same manner, these two researchers have also placed a fully integrated mathematics and science curriculum at the center of their framework. However, Lonning and DeFranco (1997, in Abell & Lederman, 2007) notes that integration happens only when the two disciplines are integrated with each other in a synergistic fashion.

Mathematics/Science Integration Continuum (Huntley, 1998)

With regard to the integration of mathematics and science, Huntley (1998) developed a continuum in order to properly describe the degree by which these disciplines overlap or coordinate with one another during instruction (Goos, Stillman & Vale, 2008). The model developed by Huntley (1998) shows that there are usually two kinds of courses by which mathematics and science interact with each other. One is a mathematics and science course that usually teaches mathematical concepts under the cover of a science context and vice versa for the science with a mathematics course (Goos, Stillman & Vale, 2008; Lederman & Niess, 1998). On the other hand however, in the mathematics and science course, the two disciplines interact and support each other, enabling students to learn more than just the content of the two.

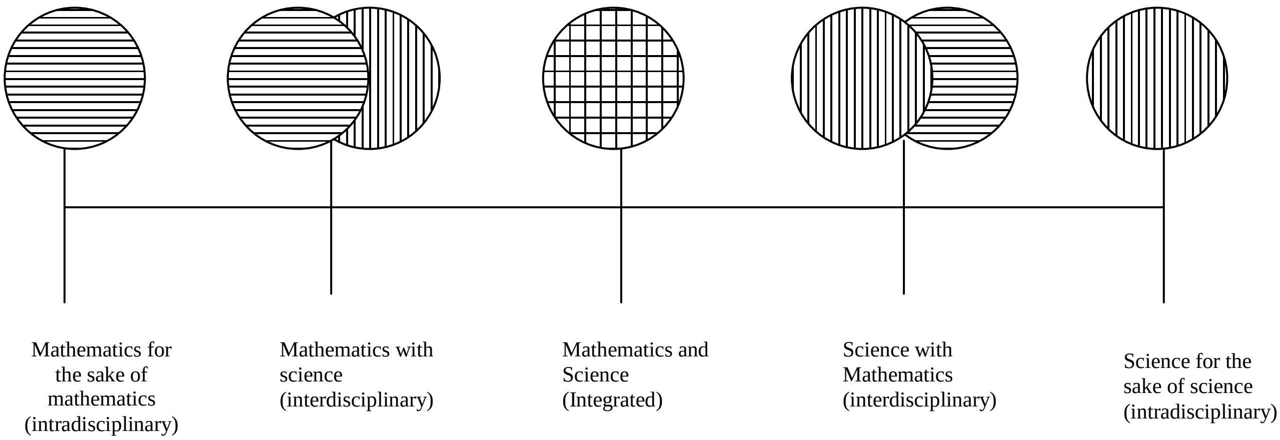

Figure 2. Mathematics/Science Integration Continuum by Huntley (1988) in Goos, Stillman and Vale (2008).

Figure 2 enables one to visualize the manner by which mathematics and science can be incorporated with one another. In contrary to the interdisciplinary approach, curriculum integration entails the fusion of both mathematical and scientific disciplines in order to ensure that new knowledge will result from this fusion.

Roebuck and Warden (1998)

The model developed by Roebuck and Warden (1998) has also concurred with earlier models in identifying five different categories wherein mathematical and scientific disciplines interact with each other (Berlin & White, n.d.). However, the model developed by the two researches has given paramount importance to the different steps that must be undertaken in order for teachers to explore and observe connections between the two disciplines (West, Vasquez-Mireles & Coker, 2006; Roebuck and Warden, 1998).

Hurley (2001)

Hurley (2001, in Abell and Lederman, 2007), on the other hand, presents a different perspective on the integration of mathematics and science. Basically, this researcher has identified five types of integration between the two, namely, sequenced, parallel, partial, enhanced and total. Sequenced integration is the kind by which science and mathematics are planned and taught preceding the other (Abell and Lederman, 2007; Berlin & White, n.d.). Meanwhile, parallel integration entails teaching both disciplines together (Abell and Lederman, 2007; Berlin & White, n.d.). On the other hand, partial integration connotes that both subjects are taught separately yet remains integrated (Abell and Lederman, 2007; Berlin & White, n.d.). Also, enhanced integration entails the teaching of one discipline while the other is used in order to augment the discussion of the former (Abell and Lederman, 2007; Berlin & White, n.d.). Finally, total integration shows that both disciplines are taught equally together (Abell and Lederman, 2007; Berlin & White, n.d.).

Berlin- White Integrated Science and Mathematics Model (BWISM)

Developed by Berlin and White (1998), the BWISM has been very popular amongst the members of both the mathematics and science education communities. This particular model has been developed from the intensive research undertaken by both scholars that reflected a comprehensive review of literature written with regard to the topic, including the perspectives of the members of both the mathematics and science communities; the different research and development projects undertaken with regard to the curriculum; and lastly, the classroom practice. Unlike the previous theoretical models developed by researchers concerning the integration of the two disciplines, the Berlin-White Science and Mathematics Model or BWISM has transcended beyond the mere description of content integration. Rather, this model has given paramount importance to the concepts that must be incorporated into the integration to ensure its effectiveness.

Generally, the Berlin-White Integrated Science and Mathematics Model or BWISM includes six very important categories; these are namely, (1) ways of learning; (2) ways of knowing; (3) content knowledge; (4) process and thinking skills; (5) attitudes and perception; and (6) teaching strategies. The aforementioned categories of the Berlin-White Integrated Science and Mathematics Model (BWISM) is said to be very important in order to ensure the successful integration of these two subjects' content.

The category ways of learning, according to Berlin and White (n.d.) refers to the need for integration to be based on how students experience, organize and perceive the two subjects, mathematics and science. According to these authors, upon the use of a constructivist/neuropsychological perspective or rationale, students must be actively involved in the process of learning in order to guarantee the success.

Ways of knowing refers to the need for an integrated mathematics and science curriculum to reinforce cyclical relationships through the use of both inductive-deductive and qualitative-quantitative perspectives of the world (Berlin & White, n.d.). According to the two authors, the said perspectives are of vital importance in the integration of mathematical and scientific and mathematical concepts for new knowledge in these disciplines are often produced through both the inductive and deductive processes. In the same manner, further investigation entails the analysis of a pattern, as obtained through qualitative and inductive means that are then translated into a rule through both quantitative and deductive means. Hence, there is a need to develop a better understanding of all process in order to ensure the proper integration of both subjects (Berlin & White, n.d.).

Content knowledge is another category identified by Berlin and White (n.d.). According to them, the knowledge of the contents of these two disciplines are of vital importance to ensure that overlapping or redundant concepts, principles, laws and theories of the two subjects are eliminated before actually integrating the two (Berlin & White, n.d.).

The integration of mathematics and science must also give paramount importance to the development of process and thinking skills. Process and thinking skills, according to Berlin and White (n.d.) such as inquiry, problem solving and higher order thinking skills play a central role in the collection and use of information in both disciplines.

Moreover, educators must also focus on attitudes and perceptions of their students with regard to mathematics and science. Teachers could also give importance to the involvement of their students to the learning process as well as the confidence of the latter in their ability to do both subjects. Once the negative attitudes and perceptions of the students toward math and science are eliminated, then it is relatively easier for the educators to instill in their students new set of values that would enable them to readily accept an integrated curriculum of mathematics and science.

The last category identified by Berlin and White (n.d.) concerned the teaching strategies. According to them, the effectiveness of integration heavily depends on the teaching methods that educators shall use in the entire process. These teaching methods must include a broad range of content, focus on inquiry based learning and problem solving in order to properly implement the integration. In the same manner, the use of laboratory instruments and other technologically advanced tools would strengthen the relationship between science and mathematics, thereby increasing the knowledge of the students with regard to the two (Berlin & White, n.d.).

The Influence of Professional development on Student Achievement

First, a focus on what has been learned in studies of the influence of teacher professional development on student achievement is important. Kennedy's (1998) literature review focusing on mathematics and science professional development programs was perhaps the first widely circulated review to address this topic. Building on the literature reviews by Kennedy and by Clewell, Campbell, and Perlman (2004); Yoon, Duncan, Lee, Scarloss, and Shapley (2007) recently conducted the most systematic and comprehensive review to date.

Yoon et al. (2007) examined studies of impacts in three core academic subjects (reading, mathematics, and science). They focused the review on studies that met the What Works Clearinghouse (WWC) evidence standards. In total, 9 studies emerged as meeting the WWC evidence standards from 132 identified as relevant. The 9 studies all focused on elementary school teachers and their students. Five studies were experiments that met evidence standards "without reservations"; the remaining four studies met evidence standards "with reservations" (one experiment with a group equivalence problem and three quasiexperiments).

On one hand, the results of the studies were promising. Pooling across the studies in which effect size was reported in terms of student-level standard deviations, the average overall effect size was .55. This average effect size looks remarkably high when compared with what is found in other studies of the influence of teacher variables on student achievement. For example, in their evaluation of Teach for America (TFA), Decker, Mayer, and Glazerman (2004) randomly assigned students to TFA teachers and to other newly assigned novice teachers. The effect size on students' mathematics scores was .26 student standard deviations.

On the other hand, these studies did not involve professional development programs delivered in a variety of settings and led by multiple trainers. Instead, the studies involved a small number of teachers, ranging from 5 to 44, often clustered in a few schools. In addition, the developers of the professional development provided it directly to teachers. Studies of this type are sometimes termed *efficacy trials,* in contrast to *effectiveness trials*. Efficacy trials take place under conditions that are conducive to obtaining an effect. In an effectiveness trial, an intervention is tested in the full range of settings in which it is designed to work (see Kellam & Langevin, 2003; Shadish, Cook, & Campbell, 2002; Society for Prevention Research, 2004). Results from an effectiveness trial are more likely to be relevant to those considering the adoption of specific professional development programs in a particular school or district.

In sum, one of the major challenges in research on the influence of professional development on student achievement is to determine whether professional development programs can be effective when delivered in typical settings by those not involved in the development of the professional development programs. This is a logical step in the progression of research; it is what Borko (2004) called Phase 3 studies of professional development in her presidential address to the American Educational Research Association in 2004. She recommended that researchers continue studying teacher professional development programs and commended their efforts, she also articulated a three-phase pipeline of research. The pipeline culminates in studies showing that particular professional development programs could be adopted in a range of settings, with consistent effects on teaching and learning.

The Features that make Professional Development Effective

In addition to showing that professional development could be effective, Kennedy's (1998) review sought to identify the features of effective professional development. To do so, Kennedy categorized studies according to the professional development being studied. She found that the relevance of the content of the professional development was particularly important. She classified in-service programs into four groups according to the level of prescriptiveness and the specificity of the content they provide to teachers. On the basis of her analysis of effect sizes, Kennedy concluded, "Programs whose content focused mainly on teachers' behaviors demonstrated smaller influences on student learning than did programs whose content focused on teachers' knowledge of the subject, on the curriculum, or on how students learn the subject" (p. 18). Kennedy's literature review suggested an important role for content emphasis in high-quality and effective professional development. Her seminal work prompted others to test the same research hypothesis in their subsequent studies (cf. Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Yoon, Garet, Birman, & Jacobson, 2006).

In the recent Yoon et al. (2007) review, there was relatively little variation in the features of the professional development in the nine studies that met the evidence standards for inclusion in the review, and thus the authors were unable to draw strong conclusions about the features of professional development programs that make them effective.

Despite the lack of solid evidence, drawing on various bodies of theory and correlational and case study evidence, a consensus has been built on promising “best practices” (Garet et al., 2001; Guskey, 2003; Hawley & Valli, 1998; Kennedy, 1998; Little, 1993; Loucks-Horsley, Hewson, Love, & Stiles, 1998; National Commission on Teaching and America’s Future, 1996; Showers, Joyce, & Bennett, 1987; Wilson & Berne, 1999). For example, it is generally accepted that intensive, sustained, job-embedded professional development focused on the content of the subject that teachers teach is more likely to improve teacher knowledge, classroom instruction, and student achievement. Furthermore, active learning, coherence, and collective participation have also been suggested to be promising best practices in professional development (Garet et al., 2001).

It is important to recognize that this consensus—although it has endured for more than a decade—lacks sufficient specificity to guide practice. For example, nearly everyone decries the “one shot” workshop and affirms that professional development should be “sustained” and “intensive.” And among the studies identified by Yoon et al. (2007), there is at least suggestive evidence that professional development is more likely to be effective when given in larger “doses.” But the cost of developing and delivering professional development grows proportionally with the number of days involved, and requiring teachers to be out of the classroom on regular school days is disruptive to student learning. More rigorous research designs are needed to resolve these dilemmas—by determining the relative effectiveness of professional development programs with different durations or different allocations of professional development events across time.

Another example of the need for greater specificity to guide practice is the consensus that professional development should be “school based” or “integrated into the daily work of teachers” (see Hawley & Valli, 1998; Joyce & Showers, 2002). Such professional development typically requires that a coach or mentor work with teachers at one or more schools, which is among the most expensive approaches to professional development available. With what frequency, duration, and quality would coaching or mentoring need to occur to make a difference? And suppose the budget is fixed. Should the amount of off-site professional development be reduced in order to increase the amount of school-based professional development? These are simple, practical questions faced by those who design and fund professional development initiatives.

Professional Training in Math and Science

As earlier mentioned, the integration of the subjects of mathematics and science poses many benefits for both the students and the teachers. Hence, more and more educational institutions are engaging themselves in order to undergo a revision of the curriculum that would eventually integrate both mathematical and scientific concepts in their curriculum. However, Carpenter and his fellow researchers (2004) have highlighted the importance of the role teachers or educators shall play in order to make the reforms feasible. In this sense, these authors have called for the proper training of these professionals in order to ensure that the benefits that the students will receive from content integration would be maximized (Carpenter, et al., 2004; Hanson, 2002; Roth, 1993).

The call for professional training in mathematics and science, according to Pang and Good (2000) is said to be brought about by the fact that the limited understanding of the said initiative has only brought about superficial changes. Apparently, the authors discuss that the lack of understanding prevents the teachers from successfully implementing the reforms, thus their methods do not generally meet the intent and vision of reform (Pang & Good, 2000; Wenner, 2001; Wise, Spiegel & Bruning, 1999). In the same manner, the teachers' use of pedagogical strategies and methods were also seen to reflect only social practices of the recommended methods. Due to this, it was seen that the focus they give on the said mores and norms had become insufficient for them implementation of the reform ideas (Pang & Good, 2000; Wise, Spiegel & Bruning, 1999; Bowman, Davis & Koirala, 1999; Hanson, 2002).

Carpenter, et al. (2004) state that in order to ensure that students learn mathematics and science with understanding; their teachers must know how to help them. Hence, the following should be ensured: first, the connection that exists between the knowledge they are learning to what the students already know; second, the construction of a coherent structure for the knowledge that they will soon acquire rather than just receiving a collection of isolated bits of information and disconnected skills; third, the teachers must be able to engage their students in inquiry and the solving of problems; and lastly, fourth, the educators must play an active role in validating the ideas and procedures involved in the process of learning integrated lessons in math and science (Carpenter, et al., 2004; Wise, Spiegel & Bruning, 1999; Bowman, Davis & Koirala, 1999; Hanson, 2002). This then highlights the professional training of all teachers in order to prepare them for imparting knowledge to their students effectively by using a curriculum that integrates concepts of both mathematics and science.

The concept of professional training has been treated synonymously with professional learning in the paper published by the National Council of Supervisors of Mathematics (2007). According to the said organization, professional learning, as its name implies, places the teachers in the role of the learners. Thus, it is not a mere list of professional learning offerings but a program of work by which they can properly prepare them for the so-called reform-oriented teaching practices such as content integration (the National Council of Supervisors of Mathematics, 2007). Without a doubt, professional learning enables the educators to possess more knowledge with regard to content (the National Council of Supervisors of Mathematics, 2007; DiCerbo & Duran, 2006; Wenner, 2001; Bowman, Davis & Koirala, 1999).

The National Council of Supervisors of Mathematics (2007), in their paper entitled *"Improving Student Achievement by Leading Sustained Professional Learning for Mathematics Content and Pedagogical Knowledge Development"* mentioned a framework developed by Loucks-Horsley, Hewson, Love and Stiles (1998). This particular framework is basically meant for teachers of both science and mathematics to ensure that their students are receiving professional learning. The framework encourages the use of the following elements in the planning for professional learning to ensure that the educators would be properly trained for content integration in math and science: first, professional learning must be able to possess knowledge and understanding about their students and their learning ability. Also, they are called to understand teachers and teaching; the nature of both mathematics and science; the nature of professional learning; and lastly, the process by which change would be introduced (the National Council of

Supervisors of Mathematics, 2007). Second, the educators must be able to understand the context of professional learning which is seen to be of vital importance in order to guarantee sustained and teacher learning (the National Council of Supervisors of Mathematics, 2007).

The third element that the framework incorporates is important issues that must be incorporated in all stages of professional learning. These issues include time, equity, professional culture, leadership, sustainability, and public support (the National Council of Supervisors of Mathematics, 2007). Finally, it must also be ensured that several important strategies – aligning and implementing curriculum; examining teaching and learning; immersion in both mathematics and science and content; coaching and mentoring; and lastly, collaboration with colleagues- would be considered in order to ensure the professional learning of educators, thereby making them prepared for content integration (the National Council of Supervisors of Mathematics, 2007).

Concurring with the discussions presented by the National Council of Supervisors of Mathematics (2007), DiCerbo and Duran (2006) also highlighted the relationship between knowledge of the content and professional development. This basically calls the educators to become experts in their field so as to ensure that they could teach the subject matter more effectively by incorporating different techniques.

Carpenter and his colleagues (2004) in their quest to ensure that the professional development of the educators are guaranteed, introduced the need to forge connections among three bodies of knowledge; these are the following: (1) the critical concepts, processes and methods of inquiry and argumentation of the content they are teaching; (2) the ways by which the mathematical and scientific thinking of the students develop; and lastly, (3) the nature and effects of their teaching practices. In this sense, the authors mentioned different ways by which these could be achieved by highlighting several researches conducted in relation with the topic. According to them, there were some educators that were first trained to study specific mathematics or science ideas. It was through this that the teachers were expected to develop models by which the thinking skills of their students could be improved with regard to specific topics in both mathematics and science (Carpenter, et al., 2004). On the other hand, there were also those who made use of the method of discourse in order to ensure the connection of mathematical and scientific knowledge in their discussions. Despite the differences of the techniques, Carpenter and his fellow researchers (2004) have highlighted the importance of professional development programs in order to ensure the better understanding of the students. In this professional development, the following must be ensured: (1) integrated student thinking; (2) knowledge of mathematics and science and content; and lastly (3) instructional practice.

Furner and Kumar (2007) also support the need to efficiently prepare the educators for teaching an integrated math and science curriculum. For these authors, the teachers must be able to receive adequate training in order to maximize the benefits of the said efforts to the students. In relation to this, the following were recommended by Furner and Kumar (2007): (1) teachers should have an understanding of the subject field they will be teaching as well as the needs expected from them; (2) to have a better understanding of the methods that may be required of them in teaching an interdisciplinary subject matter; and lastly, (3) the need to be informed with certain strategies that would effectively encourage the students to participate actively in the lessons (these, according to Furner and Kumar (2007) may include the need to use process skills such as reading, writing, reporting, research problem solving, mathematical application, data collection, data analysis and the drawing of conclusions).

Furner and Kumar, West, Vasquez-Mireles and Coker (2006) have acknowledged the existence of barriers that prevent the successful integration of mathematics and science. These barriers have often been identified in relation to the attitudes and perceptions of the teachers. In fact, Huntley (1998) lists several factors that often stem from the teachers' negative perceptions of curriculum integration; these include the following: (1) increased time; (2) coordination of students; (3) availability of instructional models; and lastly, (4) the availability of appropriate curricular materials. This then results to the lack of communication between the teachers thus negatively affecting the integration of the two disciplines. As a result, it has been recommended that teachers be greatly exposed to settings that integrate both disciplines. In this manner, they will be able to properly identify the concepts between each other, eliminate the redundant ones, thus ensuring a successful integration that would surely benefit the students (West, Vasquez-Mireles & Coker, 2006).

The claim previously mentioned has been supported by Frykholm and Glasson (2005). According to the two, the teachers' knowledge of the content is of vital importance in order for them to develop the necessary pedagogical strategies in order to handle the redundant and overlapping concepts in the disciplines' content. Aside from this, the authors further recommend professional training in additional coursework in order to enhance the teachers' knowledge regarding the two disciplines (Frykholm & Glasson, 2005).

The Council of Chief State School Officers (2006) has also reiterated the importance of professional development in order to guarantee the success of the integration of mathematical and scientific disciplines. According to the said organization, the development of the teachers as well as the support they receive should be placed at the center of reforms in the field of mathematics and science, including content integration. In fact, the Council of Chief State School Officers (2006) has proposed the different steps to be undertaken in order to prepare the educators for teaching integrated math and science.

The council first called for the promotion of professional development that is designed in such a way that it would ensure education in mathematics and science as ongoing, school-based and focused on curriculum as well as the instruction method used by the school. Programs under such professional development programs must be continuous and at the same time, enable the teachers to keep up with emerging mathematics and science content (Council of Chief State School Officers, 2006). Moreover, the programs must also be able to develop strategies by which instruction can be made more effective.

The council also calls for a review of recruitment strategies, initial certification and recertification procedures and policies. They believe that it is through the aforementioned that the selection of the teachers would be more appropriate. At the same time, this could also help in the promotion of the growth and development of both teachers and principals (Council of Chief State School Officers, 2006).

The development of policies and structures that would furnish both mathematics and science teachers with the necessary knowledge and skills in order to address the varied needs of the students was also seen to be significant. According to the Council of Chief State School Officers (2006), this would significantly improve the performance of all the students as the educators will finally learn on how to adapt depending on the needs of his or her students. Also, it is through one's open-mindedness with regard to this that the educators will be more involved in the search for a technique and/or method that would be effective and beneficial in teaching an integrated mathematics and science subject.

Finally, the use of technology is also perceived as necessary in order to support the professional development programs aimed towards the betterment of teachers. Apparently, the Council of Chief State School Officers (2006) has deemed this to be necessary in both instruction and assessment. Aside from this, the use of the tools can also help the students gain a better understanding of the topic at hand, most especially with regard to abstract concepts that are perceived to be most common in the field of mathematics and science (Council of Chief State School Officers, 2006; Ruberg, Chen and Martin, n.d.).

Trammel (2000) further calls for more support for teachers who will be teaching an integrated mathematics and science curriculum. This is because, according to him, the manner by which these subjects would be taught is very different from the traditional way of teaching the subject. These differences usually stem out from the structure of the lessons. An integrated curriculum usually begins with a context-based problem. As the lesson progresses on, new concepts begin to surface as the students engage themselves in problem-solving. For Trammel (2000), the teacher must be able to ensure that the students adapt to these changes so as to help them in gaining a better understanding of the usefulness of both subjects.

The nature of the professional development being implemented in Georgia MSP grants is examined using an analytic framework based on the National Evaluation of the Eisenhower Professional development Program (Desimone et al., 2002; Garet, Birman et al., 1999; Garet, Porter et al., 2001; Porter et al., 2000). The framework is organized around six features of high quality professional development that were identified in that evaluation of mathematics and science programs: duration, activity type, collective participation, content focus, active learning, and coherence. The first feature involves program duration and frequency. In essence, this is the number of hours of professional development provided by the project and the spans of time are adequate to enable teachers to learn new ideas and incorporate them into their practice. The second feature is activity type. Traditional activities are more likely to take place outside of the school, while reform activities are more likely to be integrated into teachers' work. Collective participation among teachers is the third feature. The project provides opportunities for participants to work with other teachers from the same school or district. The fourth feature is content focus. The professional development is grounded in subject matter and addresses how to teach specific content to students. Furthermore, emphases are placed on content knowledge, how student learn specific content, and methods of teaching specific content. The fifth feature is active leaning and its key components are: teachers observing or being observed, planning for classroom implementation, reviewing student work, and conducting presentations or writing plans and reports. The final feature of the framework is coherence. Coherence ensures that the project activities are connected to other professional development, align with standards, and support ongoing communication. The Eisenhower criteria are not based on conclusive evidence that the six identified features of professional development cause improvements in teacher knowledge or practice. In general, the field of professional development lacks such evidence because evaluations have typically focused on participants' satisfaction with their experiences and self-reports of impact. Programs such as the Mathematics and Science Partnerships are intended to begin filling this gap in the knowledge of effective professional development.

The Impact of Content Integration on Student Achievement

According to Czerniak et al. (1999), there are only a small number of empirical researches undertaken on how an integrated curriculum can be better than a traditional one with regard to the increase of the student's achievement. These authors assume that this is because of the fact that a variety of research questions could arise when one undertakes this particular study. Nonetheless, the few research studies that had been undertaken to investigate the relationship between content integration and student achievement have all highlighted the benefits that the learners may receive from being educated within such curriculum. In fact, student achievement is one of the reasons why content integration of mathematics and science had become so popular (Wang, 2005). Furner and Kumar (2007), in their study entitled *The Mathematics and Science Integration Argument: A Stand for Teacher Education* has identified the so-called separate subject approach to knowledge and skills as one of the most fundamental problems being experienced by schools in recent times. This is because of the fact that students have the tendency to misunderstand the problems because they do not comprehend the context by which the former are embedded.

In this case, the separate subject curriculum can be compared to a jigsaw puzzle without any picture (Furner & Kumar, 2007). On the other hand, however, when subjects such as math and science are properly integrated with each other, then the learning context will be enriched as the overlapping concepts and principles are in a way fused effectively (Furner & Kumar, 2007). Through this, the students will see the relevance in their lessons, thereby making them more motivated to attend school, thus significantly affecting their performance in their subjects (Furner & Kumar, 2007; Czerniack, et al., 1999; DiCerbo and Duran, 2006; the National Council of Supervisors of Mathematics, 2007; Carpenter, et al., 2004; Pang, 2000).

Furner & Kumar, Czerniack, DiCerbo and Duran, Carpenter, and the National Council of Supervisors of Mathematics are highly supported by Burrill and Kennedy (1997). According to them, the students need to be educated within well-designed, comprehensive and coordinated experiences that integrate mathematics and science in order to learn very important concepts related to the two disciplines. Thus, it is through this that a better understanding of the two subject areas is guaranteed, thereby positively influencing the achievement of the students.

Meier, Marsha and Cobbs (1998) have also highlighted the major effects of content integration on the students' achievements. According to them, these benefits are brought about by the fact that the integration of mathematical and scientific disciplines have been brought about by the enhancement of the students' skills such as observation, classification, measurement and hypothesizing.

Historical Background of Math and Science Integration

This subsection covers the historical background of the call for the integration of mathematics and science in the United States of America in order to ensure the quality of education being given to the students. In the same manner, the discussion on the historical background shall also cover the different steps and efforts undertaken in guaranteeing the successful integration of the two subjects.

The issue with regard to the need to integrate the disciplines of science and mathematics, according to Berlin and White (n.d.) dates back to the early twentieth century. However, these authors mentioned that even though literature written dates back to 1905, it remains complicated, inadequately defined and studied. This is because of the fact that most studies conducted with regard to the two focused only on the theoretical models explaining such integration. Nonetheless, the call for the application of an interdisciplinary curriculum that integrates the disciplines of mathematics and science has believed to have stemmed out from the belief that it is the panacea for American education, a way to prepare American students for the next century (McKinney, 1993; Thomas, 1996). It was believed to have first surfaced upon the establishment of the Central Association of Science teachers in order to maintain a better correlation between the two.

Reforms in math and science education, however, began with the development of the National Council of Teachers of Mathematics (NCTM) Standards (Weiss, 1994). Mathematics teachers, educators and mathematicians all worked under this particular group and began to develop two documents: (1) the Curriculum and Evaluation Standards for Mathematics in 1989 and (2) the Professional Standards for Teaching Mathematics in 1991. These two documents then, according to Weiss (1994), the said documents have been responsible for calling for revolutionary changes in the curriculum of mathematics.

In fact, it has highlighted the need to shift away from a curriculum that only gives importance to computation and the memorizations of facts and processes to something that ensures that all students actively participate as they search for the development of their own mathematical power (Weiss, 1994). Aside from this, Weiss (1994) noted that the students during those days were encouraged to make use of skills such as exploring, conjecturing, analyzing and applying mathematical concepts both inside the classroom and in the real world. Through this, the students were encouraged not to simply make use of textbooks and the lectures of the teachers as the only sources of mathematical information (Weiss, 1994).

Aside from the people involved in mathematics education, the members of the science education community also met in 1992 in order to establish better standards for science curriculum, teaching and assessment under the auspices of the National Research Council. They came up with the document entitled *"National Science Education Standards"* wherein their vision for better science education was reflected. According to Weiss (1994), the contents of the said documents basically concurred with the statements issued by the National Council of Teachers of Mathematics. Hence, it was safe to say that both communities have agreed that the education of students with regard to both mathematical and scientific concepts must accomplish the following, as enumerated by Weiss (1994):

- Emphasize high expectations for all students;
- Focus on in-depth learning of a limited number of powerful concepts, emphasizing understanding, reasoning, and problem-solving rather than memorization of facts, terminology and

algorithms;

- Integrate the nature and process of scientific and mathematics inquiry with knowledge of key science and mathematics concepts;
- Reflect sound principles from research on how students learn, including the use of cooperative learning, and questioning techniques that promote interaction and deeper understanding;
- Feature appropriate, on-going use of calculators, computers, and other technologies for learning science and mathematics;
- Empower students by enabling them to do science and mathematics, and increasing their confidence in their ability to do so;
- Develop in students the scientific and mathematical literacy necessary to make informed decisions and function as full participants in society;
- Assess learning as an integral part of instruction;
- Ensure that teachers have a deep understanding of their subject matter; and
- Provide on-going support for classroom teachers, including continuing opportunities for teachers to work with one another in planning curriculum and instruction.

Berlin and White (n.d.) further mention the various documents published in the United States that recommend content integration and instruction needed within a changing curriculum. These are the following: (1) “Principles and Standards for School Mathematics: Discussion Draft”, as published by the National Council of Teachers in Mathematics in 1998; (2) “Reshaping School Mathematics: A Philosophy and Framework for Curriculum,” published in 1990 by the National Research Council; (3) Rutherford and Ahlgren’s (1990) “Science for all Americans”; (4) the American Association for the Advancement of Science’s (1993) “Benchmarks for Science Literacy; and lastly, (5) “National Science Education Standards” as published by the National Research Council in 1996.

Calls for an integrated mathematics and science curriculum have been largely brought about by the decline in student achievement in mathematics and science that have raised concern for continued national strength in an international business place, Thomas (1996) discusses.

Presently, documents that are aimed towards the integration of the mathematical and scientific disciplines are only focused on the need to apply the interdisciplinary approach (Pang & Good, 2000). More or less, the interdisciplinary approach is said to be only strengthened by the need to use science as a form of inquiry and mathematics, as a means by which problems are solved.

Related Research

Recognizing the importance of the integration of mathematical and scientific contents as provided by theoretical and historical backgrounds, the issue has become of vital importance. In fact, much research had been undertaken for more than three years with regard to the teaching of related science and mathematics concepts through integration. As repeatedly mentioned, this integration not only enhances learning as mathematics is traditionally considered to be the language of science, but also allows students to improve their understanding on both subject matters (Sahin, 2007; Basista, 2002).

This section shall cover the different studies undertaken by researchers with regard to the following themes: first, the integration of mathematical and scientific concepts; second, the manner by which teachers are prepared for the teaching of an integrated subject; and last, the effects of content integration on the performance of the students in school. The researcher has acknowledged the fact that only a limited number of studies had been accomplished in the examination of the integration of mathematical and scientific concepts. This is largely brought about by the fact that most literature written in connection with the topic only dealt with the theoretical underpinnings of the topic, as discussed in the previous sections of this chapter (Berlin & White, n.d.; Thomas, 1996; Meier, Nicol & Cobbs, 1998).

Pang and Good (2000) further cite the following as the major issues concerning related research in the field of integration of the mathematical and scientific disciplines: (1) there was a profound lack of research documents; (2) most studies were science instructional activities that incorporate mathematics-related concepts at the elementary and middle school levels; (3) the curriculum and instructional integration of mathematics and scientific disciplines are often developed based on the topic rather than intent; and lastly, (4) there were insignificant attempts to fully examine the integration of mathematics and science education. However, researchers only deal with the effect of integration on achievement or on the attitude of students toward science and mathematics but not both (Pang & Good, 2000).

In 1997, Ercikan and her colleagues also investigated on the effects of mathematics and science content integration on the integrity of both disciplines. The researchers made use of a data obtained from the Maryland Performance Assessment Program or MSPAP in 1994. Through this, Ercikan et al. (1997) were able to examine the effects of mathematics and science integration to the validity and reliability of the scales of both disciplines. The results of their study show that despite the different actions undertaken in order to integrate both, the integrity of both disciplines remain intact. It is then no doubt, that the results obtained by Ercikan and her colleagues strengthen the claim that the said disciplines can be joined together as it more or less make use of the same constructs. The researchers further state that each discipline’s use of similar cognitive processes also allows for the successful integration of the concepts that each use (Ercikan, et al., 1997).

Also mentioned earlier was the need to significantly alter the perceptions and attitudes of the educators in order to ensure the effective content integration of both the mathematical and scientific disciplines. McGinnis, McDuffie and Graeber (2006) present the importance of a pedagogical strategy to an integrated curriculum of mathematics and science. According to these researchers, the importance of teacher preparation has often been completely overlooked. Hence, their research has focused on the effects of the application of the said pedagogical strategy to ensure the success of mathematics and science integration.

Central to their study was an elementary science methods course instructor that aims to connect mathematics and science. Two groups had been used in order to arrive at a conclusion; one of which is taught with an integrated curriculum, while the other, taught in the traditional sense. The perceptions of the two groups, according to McGinnis, McDuffie and Graeber (2006) varied. Nonetheless, four elements were identified by which the performance of those receiving integrated integration was better than that of their counterparts; these are namely, (1) an appropriate learning environment; (2) the extent by which the instructors modeled the good teaching of science and mathematics; (3) the extent to which the students observed the connections made by their instructors with regard to mathematics and science; and finally, (4) the rationale behind the need to connect both disciplines together.

The study conducted by Judson and Sawada (2000) features the content integration of scientific and mathematical disciplines. West, Vasquez-Mireles and Coker (2006) note that the study authored by the two used science inquiry-oriented activities with data generating technologies in order to integrate math in one eighth-grade science class. The teacher of the said class first attended a seminar wherein he was taught how to use Calculator Based Laboratories, a data collection tool that allows students to collect and analyze information without having to use computers or calculators (West, Vasquez-Mireles & Coker, 2006).

Upon the completion of the said seminar, the class was divided into two: the experimental group wherein the students learned science as integrated with math; and the control group which was only taught with science. Nonetheless, the two groups received constant regular mathematical classes (West, Vasquez-Mireles & Coker, 2006).

In teaching the experimental group, the teacher made use of a variety of devices in order to efficiently integrate mathematics to the science class. After a period of time, a statistics unit test was given to both groups in order to determine how the integration affected the performance of the students in mathematics class. West, Vasquez-Mireles and Coker (2006) reveal the results of the study conducted by Judson and Sawada (2000) show that integration positively affected the students' performance in their mathematics class:

> While only thirty five percent of the students in the control group had grades of an A or B on the mathematics statistics unit test, seventy five percent of the students had grades of an A or B in the experimental group (Judson & Sawada, 2000, West, Vasquez-Mireles & Coker, 2006).

However, the study reveals that no difference was evident in the science performance between the students in the integrated science class and those from the non-integrated class (Judson & Sawada, 2000, in West, Vasquez-Mireles & Coker, 2006).

One of the most popular studies the positive effects of mathematics and science integration on student achievement was authored by Marlene Hurley (2001). According to Peterson and Joslin (2004), the study as constructed in such a way that it would answer the question: does the integration of mathematics and science result in greater achievement and with what kind of integration and grade levels are positive effect sizes realized? In the attempt to obtain an answer to the said research question, Hurley (2001) made use of thirty-own studies that were selected to represent thirty-four achievement outcomes with regard to the integration of the mathematical and scientific disciplines throughout all levels, from Kindergarten through College (Peterson & Joslin, 2004). More specifically, the case studies were directed towards the examination of five different types of integration, as earlier discussed in the presentation of Hurley's theoretical model.

The five different types of integration examined were the following, as enumerated by Hurley (2001) and Peterson & Joslin (2004): (1) sequenced – the planning and teaching of science and mathematics sequentially; (2) parallel – the planning and teaching of science and mathematics simultaneously, through the use of concepts that are parallel; (3) partial – the teaching of science and mathematics together and at times, as separate disciplines in same classes; (4) enhanced – one is chosen to be the major discipline of instruction; while the other, only apparent throughout the discussion; and lastly, (5) total – wherein mathematics and science are taught together, with the same level of equality.

The results of the study showed that effects of different levels of content integration on student achievement vary (Hurley, 2001; Peterson & Joslin, 2004). The sequenced type of integration has produced a positive numerical value for both science and mathematics. On the other hand, negative effects resulted from a parallel integration. Enhanced integration has also resulted to a medium positive effect of science and a small positive effect for mathematics. Finally, the total integration of the two subjects also had a large effect on the students' achievement in science while only a small positive effect in mathematics. Without a doubt, the study has highlighted the positive effects of content integration on the achievement of the students (Hurley, 2001; Peterson & Joslin, 2004). The study, most unfortunately, was not able to report whether these positive effects had been sustained over time. Nonetheless, in spite of this fact and the presence of different kinds of integration, the fusion of mathematical and scientific concepts has resulted to major student achievement, as revealed by the study of Hurley (2001, in Peterson & Joslin, 2004).

Summary

This literature review covered three very important topics in the discussion of the integration of mathematical and scientific concepts. These topics included the following: first, a theoretical background that explained concepts pertaining to the integration of the two subject matters, the professional development of the educators, and finally, the effects of integration on the achievement of the students; second, a historical background that looked into the fairly long history of the clamor for content integration in the field of mathematics and science; and lastly, a review of related research undertaken with regard to the topic at hand.

Basically, the theoretical background provided by the researcher showed the different reasons behind the need to integrate mathematics and science. While some researchers argue that the existence of an interrelationship between the two must be enough in order to treat the subjects as one, others claim that the real world is not separated into different disciplines. As a result, the students must be trained in order to think holistically even while inside the classroom. Furthermore, the literature reviewed also revealed that mathematics and science can work with each other in order for students to gain a better understanding of their disciplines. In fact, as stated, scientific concepts can solidify the abstract ideas of mathematics. Furthermore, mathematics can serve as a language by which the different scientific concepts can also be explained. It is in this regard then that the need to integrate the two has been highlighted.

This literature review has also focused upon two models that explained the integration of both mathematical and scientific concepts: Huntley’s Mathematics/Science Integration Continuum (1988) and Berlin-White Integrated Science and Mathematics

Model (BWISM). The Mathematics/Science Integration Continuum of Huntley (1988) has differentiated the interdisciplinary approach from integration. According to this author, while the former refers to the teaching of one subject matter under the cover of another, the latter incorporates both concepts in order to make both subjects one. The Berlin-White Integrated Science and Mathematics Model (BWISM) on the other hand, present six very important aspects that educators must consider in order to ensure the proper integration of both disciplines.

Because of the relative difficulty of integrating both disciplines, researchers have highlighted the importance of training teachers in this field in order to ensure that their students receive the benefits of an integrated mathematics and science curriculum. Some researchers deem it necessary to educate teachers on one specific field first before going to another in order to guarantee their knowledge with the components of the new curriculum. On the other hand, however, other researchers have given importance on the necessity of training the teachers effectively so as to ensure that they are actively prepared for this new undertaking.

With regard to student achievement, it has been said that this is one of the reasons why the integration of mathematical and scientific concepts had been very popular as a means of reforming the curriculum over the past century. Some researchers have highlighted the positive relationship between the two. However, as Pang and Good (2000) noted in the discussions made earlier, there are also researches that demonstrated the positive effects on the attitudes and perceptions of students with regard to the two subjects. In this case, there is a call for researches to investigate on both effects rather than merely focusing on student achievement.

The historical background, on the other hand, recounts the rise of movements that call for the integration of the disciplines of mathematics and science. As previously discussed, calls for the integration of the said subject has started in the early twentieth century, believing that it is through this that the achievement of the students be enhanced, which during that time was deteriorating. Aside from this, it was also through the integration of both disciplines that the students will be prepared for the demands of the next centuries. However, despite the long history of the said initiative, only a small body of research exists that deal with the topic most especially with the studies of scholars for only theoretical underpinnings have been investigated on.

The historical background of content integration also revealed that there is a tendency for the initiative to only be adopted using an interdisciplinary approach. In this sense, science is used only as a form of inquiry while mathematics, a problem solving device.

Overview of the Georgia Math and Science Partnership (MSP) Grant Program

The Georgia Department of Education expects MSP projects to use funds to (a) enhance teacher instructional capacity in the targeted grade bands, particularly in tested mathematics and science content areas; (b) increase the number of teachers who participate in cohort-based mathematics and science professional learning; (c) produce a cohort of grades 3-5 teachers with certification endorsements in mathematics and/or science; and (d) involve building-level administrators meaningfully in MSP follow-up mathematics and science professional learning opportunities. Projects are expected to accomplish these goals through several key features: clearly defined partnerships, carefully delineated work plans, and comprehensive evaluation plans that employ both formative and summative measures.

Key Features of the Georgia MSP Program

Partnership

The success of individual MSP projects rests squarely on the strength of the partner relationship. Each member of the project management team is expected to be actively engaged in the project effort at both institutional and individual levels, as well as share goals, responsibilities, and accountability for the program. The project management team must be convened regularly to oversee the design, implementation, and evaluation of the project. Furthermore, each partnership is expected to draw upon the expertise of all of its members through STEM faculty, teacher training faculty, and local school system staff members' collaborative facilitation of each MSP professional learning session.

In addition to the expectations described above, funding preference is given to partnerships that provide clear evidence of the following characteristics:

- **Commitment:** Partnership members must demonstrate commitment to project goals and projected outcomes unique to its proposal. Commitment is illustrated by each partner's clear description of the expertise, time, and resources it will provide to support the goals of the partnership. Commitment is also evidenced by the descriptions of anticipated benefits included in each partner's Memorandum of Understanding (MOU). While matching funds are not required, in-kind support is highly desirable and preference will be given to proposals in which partners contribute their own resources, including the coordination of other applicable grants, toward the project's success.
- **Sustainability:** Partnerships must provide a clear description of long-term plans

to use project data to determine its impact on teaching and learning and to support the continuation of the project model beyond the duration of the grant.

- **Capacity:** LEAs must describe specific and achievable plans to recruit, serve, and retain a teacher cohort group with increased ability to improve student achievement in tested mathematics and science content areas. A detailed description of the people and institutional resources available to conduct the project's activities and how the expertise of each will contribute to the achievement of the project's goals.

Work Plan

MSP Project partnerships are expected to immerse teachers in a multi-year program of rigorous and appropriate courses and experiences that provide coherent study within a particular mathematics or science content area. Such programming should incorporate a number of elements:

Scientifically-based Research: Project design must be informed by current research and studies on teaching and learning. Scientifically-based research involves the application of rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs. This research base should provide a rationale for the chosen professional learning model.

Cohort Approach: Projects must be designed to provide long-term professional learning opportunities to a cohort of teachers over multiple years. The goal is one program for each grade band of teachers over the course of the 2-year project time span.

Grade Bands: Projects may focus their efforts on mathematics and/or science teachers of grades 3-5, 6-8, and/or 9-12 based on identified needs. A separate needs assessment, work plan, and evaluation plan must be evident within the proposal for each grade band of teachers with whom the partnership proposes to work.

Professional Learning Plan Design: MSP projects must be designed to deliver at least 80 hours of ongoing professional learning to each teacher in the cohort group each year in the form of both intensive professional learning activities and follow-up training and classroom support. Intensive training is intended to improve the content knowledge and teaching skills of teachers while classroom follow-up training and support is intended to infuse the knowledge and skills gained directly into the classroom to benefit students. Classroom follow-up support and training must be directly related to the focus of the intensive training. Members from each of the partnership organizations must actively participate in both the classroom-level follow-up support as well as the intensive phase of the program. Of the 80 total hours of training provided to each teacher per year, at least 60 must be devoted to intensive training institutes and 20 to follow-up training and support.

<u>Project Evaluation and Accountability Plan</u>

Georgia's MSP projects are expected to use both formative and summative assessment methods to evaluate effectiveness. In the formative sense, evaluation should provide evidence of the strengths and weaknesses of the program, informing the partnership's understanding of what works and what does not in order to guide program modifications as needed. Such assessment should largely be provided by each project's formal evaluator. In the summative sense, common assessment tools are utilized across all projects to assist the Georgia Department of Education in evaluating and providing feedback on the overall state level project as well as to inform individual partnerships of the effectiveness of the totality of their work.

The Georgia Department of Education has determined that LEAs will use the *Learning Mathematics for Teaching (LMT)* instruments to evaluate professional learning in (a) numbers and operations, (b) geometry, and (c) patterns, functions, and algebra for grades 3-5 and 6-8 mathematics. LEAs use the *Project MOSART* instruments to evaluate professional learning in (a) physical, earth, and astronomy science for grades 3-5 and 6-8; and (b) physics, chemistry, earth science, and astronomy science in grades 9-12. The Georgia Department of Education continually seeks quality instruments to evaluate the effectiveness of professional learning in high school mathematics and life science. Although the Georgia Department of Education provides assessments measures for the effectiveness of professional learning, this research study attempted to quantify and correlate student achievement levels with the overall evaluation of the program.

Chapter 3

Methodology

Basic Research Design

This quantitative study examined to see whether pre and post-formative assessments can accurately reflect a quantifiable measure of instructional improvement in mathematics and science for teachers who participated in a Title II math and science partnership grant. The purposes of chapter 3 are to describe the: (a) sample population selected for this study; (b) instruments that were administered for data collection; (c) methods, materials and procedures utilized to implement and collect the data for the study; and (d) selection and use of statistical procedures employed in the analysis of the collected data.

This causal-comparative quantitative study was designed to determine if teacher participation in the Title II math and science partnership grant has a positive impact on mathematics and science student achievement levels. Twenty 3rd grade teachers participated in the one year professional learning. For research purposes, a baseline year of student achievement data was analyzed from the teachers' students prior to their participation in the professional development. The second year's data reflects the teachers' students' academic performance while the teachers participated in the professional learning. The third year's data is composed of post-professional learning student achievement data. Since the teachers had different students every year and the looping of student classes did not occur, no single student cohort could be tracked and analyzed. Therefore, the teacher's instructional effectiveness was evaluated and quantifiably measured. For each year studied, individual student scores were analyzed. Each student had three pre and post test scores for each year. The total sample population was 1,200 students yielding 3,600 test scores. For the three years worth of scores, the following statistical processes were performed: ANOVA f-tests, means, standard deviations, frequencies, Levene's tests, Kolmogorov Smirnove tests, Box M's, and finally, paired sample *t*-tests. The following research questions and hypotheses guided the study:

Research Question 1 (RQ1a-f) explored if there was a statistically significant difference in change scores among the three 9-week grading periods in math and science for each year studied. Research Question 2 (RQ2a-f) also sought to determine if a statistically significant difference in change scores existed between 9-week grading periods by year. Finally, Research Question 3 (RQ3a-b) focused upon the differences among the average gain across years 1, 2, and 3 of the study. The hypotheses for Research Question 1 (RQ1a-f) are for math and science, in Year 1, 2, and 3, there are statistically significant differences in the change scores among the three nine-week grading periods. The hypotheses for Research Question 2 (RQ2a-f) are for math and science, there are statistically significant differences in the first, second, and third nine-week change scores among years 1, 2, and 3. Finally, the hypotheses for Research Question 3 (RQ3a-b) are for math and science, there are statistically significant differences among the average gains across years 1, 2, and 3.

Preliminary Procedures

Prior to the implementation of this study, a thorough review of literature was completed. The review of literature explored the integration of math and science into the curriculum. The researcher sought to investigate the effects of content specific professional learning to the achievement of students. The review of literature was divided into four parts: (1) the theoretical background of the topic; (2) its historical background; (3) related research conducted with regard to the integration of math and science as well as the effects of the said integration to student achievement; and finally, (4) the summary of all main points enumerated in the chapter. The divisions of the literature review reflected the main issues that are related to the research; these were the following: (1) math and science content integration; (2) professional training in math and science; and finally, (3) the impact of both on student achievement.

Selection of the Sample

Twenty third grade teachers within the researcher's school district were chosen for the study. The teachers were housed at three separate elementary schools within the researcher's school district located in northern Georgia. The school district has the following socioeconomic and demographic profile. The entire school district has 4,200 students. There is one high school, two middle schools, three elementary, and one primary school. There is also a Head Start program and a state-funded pre-K program as well. One alternative school serves the county system along with two neighboring counties in a cooperative agreement. The school district is 87% Anglo, 11% Hispanic, and 2% Multi-Racial. All of the schools within the district are Title I School-wide qualified schools and the poverty average for all campuses is 56% receiving free and reduced lunch prices. The teachers studied were all female and Caucasian and their teaching experience was as follows: (9) 1-5 years experience, (7) 6-10 years experience and (4) 11-15 years experience.

The twenty third grade teachers all participated in the Title II Math and Science Partnership (MSP) grant. Since no teacher taught the same students from year to year, each teachers' students' performance were statistically tested for each year—the year prior to participation, the year during participation, and finally, the year after participation.

Instruments Used in the Data Collection-Formative Assessments

The formative pre and post assessments are developed collaboratively among content area teachers and content literacy coaches. A 70,000 question bank is accessed and items are chosen based upon performance standard correlation and a content validity measurement assigned by the providing vendor. Assessments are multiple-choice by design and typically have 25-30 questions each but comprehensive in relation to the standards being measured for that particular quarter. Student performance is then compiled and analyzed via the vendor's software (Testgate), and teachers along with instructional leaders are able to plan instructional units in relation to the students' level of mastery. To assure item validity in Testgate, a team of content experts led by a psychometrician has reviewed the correlation between each item and its designated curriculum standard. A description of the alignment process is provided in response to Question Two, below. As new items are added, they too are reviewed by the psychometrician and their team. Thinkgate also provides item difficulty data (p-values) for each item. If a value of .2 is assigned, fewer students correctly answered the item. If a value of .9 is assigned, more students correctly answered the item. At the beginning of the item review process, Thinkgate had over 35,000 items in its bank of items. Each of the items were aligned to one state content standard - the original standard to which it was written which in the majority of cases was a Georgia GPS or QCC standard. The purpose of the review process was to first evaluate the question's face validity and second to verify authenticity of the original mapping. Thus, at the end of the 2-phase process, the 35,000+ items were individually reviewed for content validity and standards alignment. Using Thinkgate's online system, a content expert first reviews an item to evaluate its quality and determine whether it should remain in the active bank of items for subscribers' use. A reviewer could select one determination per item - approved, reject, or reject for revision. Reviewers were allowed to make minor grammatical edits as part of their review. Items that needed involved revisions and edits were classified as 'reject for revision'. The reviewers also assured that stimuli or addenda (e.g., passage, table, graphic) appropriately matched its associated item(s). Grade level appropriateness and reading level were judged as either appropriate or inappropriate using the state content standard as a guide.

Procedures

The researcher identified the third grade students that were enrolled in teachers' classrooms who participated in the Title II MSP grant training. Using the district's student information database, the researcher filtered the data in order to extrapolate only students who had valid test scores for the academic years pertinent to the study. The students' formative assessment scores in mathematics and science were collected and entered into an excel spreadsheet. The students' personal data was protected by deleting all identifying test identification numbers, names, and classroom assignments.

Data Analysis

Research Question 1a

RQ1a: For Math, in Year 1, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

$H1a_o$: For Math, in Year 1, there are no differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

$H1a_a$: For Math, in Year 1, there are differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

Research Question 1b

RQ1b: For Math, in Year 2, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

$H1b_o$: For Math, in Year 2, there are no differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

$H1b_a$: For Math, in Year 2, there are differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

Research Question 1c

RQ1c: For Math, in Year 3, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

$H1c_o$: For Math, in Year 3, there are no differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

$H1c_a$: For Math, in Year 3, there are differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

Research Question 1d

RQ1d: For Science, in Year 1, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

$H1d_o$: For Science, in Year 1, there are no differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

$H1d_a$: For Science, in Year 1, there are differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

Research Question 1e

RQ1e: For Science, in Year 2, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

$H1e_o$: For Science in Year 2, there are no differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

$H1e_a$: For Science, in Year 2, there are differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

Research Question 1f

RQ1f: For Science in Year 3, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

$H1f_o$: For Science, in Year 3, there are no differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

$H1f_a$: For Science, in Year 3, there are differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks).

To examine research question 1 (parts a-f), six repeated measures Analyses of Variance (ANOVA's) were conducted. An ANOVA is an appropriate statistical analysis when the purpose of research is to assess whether a mean difference exist on one continuous dependent variable between two or more discrete groups (independent variable). In the case of research question 1 (parts a-f), the dependent variable is the change score. The change score were calculated by taking the difference between the pre-test score and the post-test score from Testgate scores. The change score was differentiated by nine week period (first, second and third). The groups include subject (math vs. science) and year (year 1, year 2, year 3).

The ANOVA uses the F test, a ratio of two independent variance estimates of the same population variance (Pagano, 1990). The *F* test allows researchers to make the overall comparison on whether group means differ. If the obtained F is larger than the critical F, the null hypothesis is rejected. The two assumptions of homogeneity of variance and normality were assessed. Normality assumes that the scores are normally distributed and can be visually represented by a bell curve; they were assessed using the one sample Kolmogorov Smirnove test. Homogeneity of variance assumes that both groups have equal variances; they were assessed using Levene's test. The multivariate equivalent to homogeneity of variance was tested using Box's M.

Research Question 2a

RQ2a: For Math, are there differences in the first nine week change scores among years 1, 2, and 3?

12_o: For Math, there are no differences in the first nine week change scores among years 1, 2, and 3.

$H1a_a$: For Math, there are differences in the first nine week change scores among years 1, 2, and 3.

Research Question 2b

RQ2b: For Math, are there differences in the second nine week change scores among years 1, 2, and 3?

$H2b_o$: For Math, there are no differences in the second nine week change scores among years 1, 2, and 3.

$H2b_a$: For Math, there are differences in the second nine week change scores among years 1, 2, and 3.

Research Question 2c

RQ2c: For Math, are there differences in the third nine week change scores among years 1, 2, and 3?

$H2c_o$: For Math, there are no differences in the third nine week change scores among years 1, 2, and 3.

$H2c_a$: For Math, there are differences in the third nine week change scores among years 1, 2, and 3.

Research Question 2d

RQ2d: For Science, are there differences in the first nine week change scores among years 1, 2, and 3?

$H2d_o$: For Science, there are no differences in the first nine week change scores among years 1, 2, and 3.

$H2d_a$: For Science, there are differences in the first nine week change scores among years 1, 2, and 3.

Research Question 2e

RQ2e: For Science, are there differences in the second nine week change scores among years 1, 2, and 3?

$H2e_o$: For Science, there are no differences in the second nine week change scores among years 1, 2, and 3.

$H2e_a$: For Science,, there are differences in the second nine week change scores among years 1, 2, and 3.

Research Question 2f

RQ2f: For Science, are there differences in the third nine week change scores among years 1, 2, and 3?

$H2f_o$: For Science, there are no differences in the third nine week change scores among years 1, 2, and 3.

$H2f_a$: For Science,, there are differences in the third nine week change scores among years 1, 2, and 3.

To examine research question 2 (parts a-f), six Analyses of Variance (ANOVA's) were conducted. An ANOVA is an appropriate statistical analysis when the purpose of research is to assess whether a mean difference exist on one continuous dependent variable between two or more discrete groups (independent variable). In the case of research question 1 (parts a-f), the dependent variable is the change score. The change score was calculated by taking the difference between the pretest score and the posttest score from Testgate scores. The change score was differentiated by nine week period (first, second and third). The groups include subject (math vs. science) and year (year 1, year 2, year 3).

Research Question 3a

RQ3a: For Math, are there differences among the average gain across years 1, 2, and 3?

$H3a_o$: For Math, there are no differences among the average gain across years 1, 2, and 3.

$H3b_a$: For Math, there are differences among the average gain across years 1, 2, and 3.

Research Question 3b

RQ3b: For Science, are there differences among the average gain across years 1, 2, and 3?

$H3b_o$: For Science there are no differences among the average gain across years 1, 2, and 3.

$H3b_a$: For Science there are differences among the average gain across years 1, 2, and 3.

To examine research questions 3a and 3b, two Analyses of Variance (ANOVA's) were conducted. An ANOVA is an appropriate statistical analysis when the purpose of research is to assess whether a mean difference exist on one continuous dependent variable between two or more discrete groups (independent variable). In the case of research question 3a and 3b, the dependent variable is the average gain. The average gain was measured across year (year 1, year 2, and year 3). The average gain was calculated by summing the three pretest/posttest change scores (1st nine weeks, 2nd nine weeks and 3rd nine weeks) and dividing by the total number of change scores (3). The group is subject (math vs. science).

Being that the study proposed an ANOVA with a dichotomous independent variable, Subject (math vs. science), and approximately 64 participants were needed per group for a total of 128 participants. With an alpha level set at .05, 128 participants will yield a power of .80 with a medium effect size (Cohen, 1992).

Chapter 4

Research Findings

The basis of this study was to find out if student achievement levels in mathematics and science improved as a result of teachers who participated in a Title II math and science partnership grant. The research questions were evaluated along with their appropriate null hypotheses. The questions were answered by quantifying the change exhibited on formative assessments attempted by students. Since the twenty teachers studied did not have the same students from year to year, the ability to track a particular cohort was not available. Moreover, summative assessment data was too abstract and the formative assessments provided a clearer picture to measure academic achievement throughout a school year. The following research questions and null hypotheses allowed the researcher to evaluate achievement levels from the baseline year, through the learning year, and into the implementation year of the grant:

Research Question 1a

RQ1a: For Math, in Year 1, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

Research Question 1b

RQ1b: For Math, in Year 2, are there differences in the change scores among the three nine-week grading periods (1^{st} nine weeks, 2^{nd} nine weeks, and 3^{rd} nine weeks)?

Research Question 1c

RQ1c: For Math, in Year 3, are there differences in the change scores among the three nine-week grading periods (1st nine weeks, 2nd nine weeks, and 3rd nine weeks)?

Research Question 1d

RQ1d: For Science, in Year 1, are there differences in the change scores among the three nine-week grading periods (1st nine weeks, 2nd nine weeks, and 3rd nine weeks)?

Research Question 1e

RQ1e: For Science, in Year 2, are there differences in the change scores among the three nine-week grading periods (1st nine weeks, 2nd nine weeks, and 3rd nine weeks)?

Research Question 1f

RQ1f: For Science in Year 3, are there differences in the change scores among the three nine-week grading periods (1st nine weeks, 2nd nine weeks, and 3rd nine weeks)?

Results

Research Question 1a

To examine research question 1a, a repeated measures Analysis of Variance (ANOVA) was conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for Math in year 1. The main effects of change scores were significant F (2, 502) = 62.101, p<.001. Post hoc tests consisting of three paired sample t-tests revealed that the mean for change 1 (M = 0.46, SD = 0.17) was larger than the mean for change 2 (M= 0.34, SD = 0.20); the mean of change 1 (M = 0.46, SD = 0.11) was larger than the mean of change 3 (*M* = 0.33, *SD* = 0.18). The null hypothesis is rejected. The ANOVA is presented in Table 1 and the means and standard deviations on Math and Science change scores (change 1, change 2, and change 3) by year are presented in Table 7.

Table 1

Analysis of Variance for Math, Year 1 Change Scores (Change 1, Change 2, and Change 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Change Score	2	62.101	0.001	.198	0.999
Error	502	(0.021)			

Note. Number in parenthesis represents mean square error.

Research Question 1b

To examine research question 1b, a repeated measures analysis of variance (ANOVA) was conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for Math in year 2. The main effects of change scores were significant F (2, 318) = 113.118, p <.001. Post hoc tests consisting of three paired sample *t*-tests revealed that the mean for change 1 (*M* = 0.48, *SD* = 0.19) was larger than the mean for change 2 (*M*= 0.24, *SD* = 0.22); the mean of change 3 (*M* = 0.43, *SD* = 0.19) was larger than the mean of change 2 (*M* = 0.24, *SD* = 0.22). The null hypothesis is rejected for these variables. The null hypothesis is accepted for the remaining variables; the mean difference between change 1 and change 3 was not significant for Math year 2. The ANOVA is presented in Table 2 and the means and standard deviations on Math and Science change scores (change 1, change 2, and change 3) by year are presented in Table 7.

Table 2

Analysis of Variance for Math Year 2 Change Scores

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Change Score	2	113.118	0.001	0.416	0.999
Error	318	(0.022)			

Note. Number in parenthesis represents mean square error.

Research Question 1c

To examine research question 1c, a repeated measures analysis of variance (ANOVA) was conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for Math in year 3. The main effects of change scores were significant F (2, 100) = 3.612, p =.031. Post hoc tests consisting of three paired sample t-tests revealed that the mean for change 3 (M = 0.30, SD = 0.20) was larger than the mean for change 2 (M= 0.21, SD = 0.23); therefore the null hypothesis is rejected. No other differences were significant and the null hypothesis is accepted for the remaining variables. The ANOVA is presented in Table 3 and the means and standard deviations on Math and Science change scores (change 1, change 2, and change 3) by year are presented in Table 7.

Table 3

Analysis of Variance for Math Year 3 Change Scores

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Change Score	2	3.612	.031	0.067	0.656
Error	100	(0.029)			

Note. Number in parenthesis represents mean square error.

Research Question 1d

To examine research question 1d, a repeated measures analysis of variance (ANOVA) was conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for Science in year 1. The main effects of change scores were significant F (2, 408) = 108.557, p <.001. Post hoc tests consisting of three paired sample *t*-tests revealed that the mean for change 3 (*M* = 0.41, *SD* = 0.17) was larger than the mean for change 1 (*M*= 0.24, *SD* = 0.15) and for change 2 (*M* = 0.22, *SD* = 0.16). The null hypothesis is rejected. The null hypothesis accepted for the remaining variables. The ANOVA is presented in Table 4 and the means and standard deviations on Math and Science change scores (change 1, change 2, and change 3) by year are presented in Table 7.

Table 4

Analysis of Variance for Science Year 1 Change Scores

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Change Score	2	108.557	0.001	0.347	0.999
Error	408	(0.022)			

Note. Number in parenthesis represents mean square error.

Research Question 1e

To examine research question 1f, a repeated measures analysis of variance (ANOVA) was conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for Science in year 2. The main effects of change scores were significant F (2, 254) = 25.773, p <.001. Post hoc tests consisting of three paired sample *t*-tests revealed that the mean for change 3 (M = 0.44, SD = 0.21) was larger than the mean for change 1 (M= 0.34, SD = 0.18) and for change 2 (M = 0.30, SD = 0.21); therefore the null hypothesis is rejected. No other differences were significant and the null hypothesis is accepted for the remaining variables. The ANOVA is presented in Table 5 and the means and standard deviations on Math and Science change scores (change 1, change 2, and change 3) by year are presented in Table 7.

Table 5

Analysis of Variance for Science Year 2 Change Scores

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Change Score	2	25.773	0.001	0.169	0.999
Error	254	(0.025)			

Note. Number in parenthesis represents mean square error.

Research Question 1f

To examine research question 1f, a repeated measures analysis of variance (ANOVA) was conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for Science in year 3. The main effects of change scores were significant *F* (2, 234) = 18,162, p <.001. Post hoc tests consisting of three paired sample *t*-tests revealed that the mean for change 2 (*M* = 0.37, *SD* = 0.21) was larger than the mean for change 1 (*M*= 0.25, *SD* = 0.19); the mean for change 3 (*M* = 0.27, *SD* = 0.18) was larger than the mean for change 1 (*M*= 0.25, *SD* = 0.19); and the mean for change 2 (*M* = 0.37, *SD* = 0.21) was larger than the mean for change 3 (*M* = 0.27, *SD* = 0.18); therefore, the null hypothesis is rejected. The ANOVA is presented in Table 6 and the means and standard deviations on Math and Science change scores (change 1, change 2, and change 3) by year are presented in Table 7.

Table 6

Analysis of Variance for Science Year 3 Change Scores

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Change Score	2	18.162	0.001	0.134	0.999
Error	234	(0.028)			

Note. Number in parenthesis represents mean square error

Table 7

Means and Standard Deviations on Math and Science Change Scores (Change 1, Change 2, and Change 3) by Year

		Math			Science		
Year	Change Score	*N*	*M*	*SD*	*N*	*M*	*SD*
Year 1	Change 1 (1st Nine Weeks)	252	0.46	0.17	205	0.24	0.16
	Change 2 (2nd Nine Weeks)	252	0.34	0.20	205	0.22	0.16
	Change 3 (3rd Nine Weeks)	252	0.33	0.18	205	0.42	0.17
Year 2	Change 1 (1st Nine Weeks)	160	0.47	0.19	128	0.34	0.18
	Change 2 (2nd Nine Weeks)	160	0.24	0.22	128	0.30	0.21
	Change 3 (3rd Nine Weeks)	160	0.43	0.19	128	0.44	0.21

Year 3	Change 1 (1st Nine Weeks)	151	0.28	0.21	118	0.25	0.19
	Change 2 (2nd Nine Weeks)	151	0.21	0.23	118	0.37	0.21
	Change 3 (3rd Nine Weeks)	151	0.30	0.20	118	0.27	0.18

Research Question 2a

To examine research question 2a, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in change 1 (1st nine weeks) scores for Math by year (year 1, year 2, and year 3). The between subjects effects for change score 1 were significant $F(2, 863) = 10.633$, $p < .001$, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Math, the year 1 (*M* = 0.46, *SD* = 0.17) had a larger mean on change scores for the first nine weeks than year 3 (*M* = 0.39, *SD* = 0.24), and that Year 2 (*M* = 0.46, *SD* = 0.20) had a larger mean on change scores for the first nine weeks as compare to year 3 *(M* = 0.39, *SD* = 0.24), therefore, the null hypothesis is rejected. Year 3 had a lower change score than years 1 and 2. The difference between the means of year 1 and year 2 was not statistically significant, and the null hypothesis is accepted. The ANOVA's are presented in Table 8 and the means and standard deviations on change score (change 1, change 2 and change 3) by year (year 1, year 2, and year 3) for Math and Science are presented in Table 14.

Table 8

Analysis of Variance for Math Change 1 Scores by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	10.633	0.001	0.024	0.989
Error	863	(0.041)			

Note. Number in parenthesis represents mean square error.

Research Question 2b

To examine research question 2b, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in change 2 (2nd nine week change scores) for Math among years (year 1, year 2, and year 3). The between subjects effects for change 2 were significant F (2, 749) = 10.451, p < .001, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Math, the year 1 (*M* = 0.32, *SD* = 0.22) had a larger mean on change 2 than year 2 (*M* = 0.26, *SD* = 0.24), and that year 3 (*M* = 0.26, *SD* = 0.27) had a larger mean on change 2 as compared to year 2 *(M* = 0.26, *SD* = 0.24), therefore, the null hypothesis is rejected. Year 2 had a lower change score than years 1 and 3.The difference between the means of year 1 and year 3 for change 2 was not statistically significant, and the null hypothesis is accepted. The ANOVA's are presented in Table 9 and the means and standard deviations on change score (change 1, change 2 and change 3) by year (year 1, year 2, and year 3) for Math and Science are presented in Table 14.

Table 9

Analysis of Variance for Math Change 2 Scores by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	10.451	0.001	0.027	0.988
Error	749	(.055)			

Note. Number in parenthesis represents mean square error.

Research Question 2c

To examine research question 2c, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in change 3 (3^{rd} nine weeks) scores for Math among years (year 1, year 2, and year 3). The between subjects effects for change score 1 were significant F (2, 708) = 9.292, p < .001, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Math, Year 2 (*M* = 0.39, *SD* = 0.19) had a larger mean on change 3 as compared to year 1 (*M* = 0.32, *SD* = 0.18), and year 3 *M* = 0.37, *SD* = 0.23) had a larger mean on change 3 compared to year 1 (*M* = 0.32, *SD* = 0.18); therefore, the null hypothesis is rejected. Year 1 had a lower change 3 score than years 2 and 3. The difference between the means of year 2 and year 3 was not statistically significant and the null hypothesis is accepted. The ANOVA's are presented in Table 10 and the means and standard deviations on change score (change 1, change 2 and change 3) by year (year 1, year 2, and year 3) for Math and Science are presented in Table 14.

Table 10

Analysis of Variance for Math Change 3 Scores by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	9.292	0.001	0.026	0.978
Error	708	0.038			

Note. Number in parenthesis represents mean square error.

Research Question 2d

To examine research question 2d, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in change 1 (1st nine weeks) scores for Science among year (year 1, year 2, and year 3). The between subjects effects for change score 1 were significant $F(2, 722) = 15.646$, $p < .001$, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Science, the year 2 (*M* = 0.33, *SD* = 0.18) had a larger mean on change 1 scores than year 1 (*M* = 0.24, *SD* = 0.16), and Year 3 (*M* = 0.31, *SD* = 0.22) and that had a larger mean on change 1 scores as compare to year 1 *(M* = 0.24, *SD* = 0.16); therefore, the null hypothesis is rejected. Year 1 had a lower change score than years 2 and 3. The difference between the means of year 2 and year 3 was not statistically significant and the null hypothesis is accepted. The ANOVA's are presented in Table 11 and the means and standard deviations on change score (change 1, change 2 and change 3) by year (year 1, year 2, and year 3) for Math and Science are presented in Table 14.

Table 11

Analysis of Variance for Science Change 1 Scores by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	15.646	0.001	0.042	0.999
Error	722	(0.036)			

Note. Number in parenthesis represents mean square error.

Research Question 2e

To examine research question 2e, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in change 2 (2^{nd} nine week change scores) for Science by year (year 1, year 2, and year 3). The between subjects effects for change 2 were significant F (2, 727) = 72.595, p < .001, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Science, year 3 (*M* = 0.43, *SD* = 0.22) had a larger mean on change 2 than year 1 (*M* = 0.23, *SD* = 0.17) and year 2 (*M* = 0.28, *SD* = 0.22); Year 2 (*M* = 0.28, *SD* = 0.22) had a larger mean on change 2 as compared to year 1 *(M* = 0.23, *SD* = 0.18); therefore, the null hypothesis is rejected. The ANOVA's are presented in Table 12 and the means and standard deviations on change score (change 1, change 2 and change 3) by year (year 1, year 2, and year 3) for Math and Science are presented in Table 14.

Table 12

Analysis of Variance for Science Change 2 Scores by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	72.595	0.001	0.166	0.999
Error	727	(0.040)			

Note. Number in parenthesis represents mean square error.

Research Question 2f

To examine research question 2f, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in Change 3 (3rd nine weeks) scores for Science by years (year 1, year 2, and year 3). The between subjects effects for change score 3 were significant F (2, 660) = 29.375, p < .001, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Science, year 1 (*M* = 0.42, *SD* = 0.18) had a larger mean on change 3 as compared to year 3 (*M* = 0.28, *SD* = 0.20); Year 2 (*M* = 0.40, *SD* = 0.21) had a larger mean on change 3 as compared to year 3 (*M* = 0.28, *SD* = 0.20); therefore, the null hypothesis is rejected. Year 1 had a lower change score than years 2 and 3. The difference between the means of year 1 and year 2 was not statistically significant and the null hypothesis is accepted. The ANOVA's are presented in Table 13 and the means and standard deviations on change score (change 1, change 2 and change 3) by year (year 1, year 2, and year 3) for Math and Science are presented in Table 14.

Table 13

Analysis of Variance for Science Change 3 Scores by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	29.375	0.001	0.082	0.999
Error	660	(0.038)			

Note. Number in parenthesis represents mean square error.

Table 14

Means and Standard Deviations on Change Score (Change 1, Change 2 and Change 3) by Year (Year 1, Year 2, and Year 3) for Math and Science.

		Math			Science		
Change Score	Year	*N*	*M*	*SD*	*N*	*M*	*SD*
Change 1 (1st Nine Weeks)	Year 1	355	0.46	0.17	253	0.24	0.16
	Year 2	269	0.46	0.20	190	0.33	0.18
	Year 3	242	0.39	0.24	282	0.31	0.22
Change 2 (2nd Nine Weeks)	Year 1	351	0.32	0.22	286	0.23	0.22
	Year 2	244	0.25	0.24	198	0.28	0.24
	Year 3	257	0.36	0.27	246	0.43	0.27
Change 3 (3rd Nine Weeks)	Year 1	335	0.32	0.18	261	0.42	0.18
	Year 2	226	0.39	0.19	225	0.40	0.21
	Year 3	150	0.37	0.23	177	0.28	0.20

Research Question 3a

To examine research question 3a, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in average gain by year (year 1, year 2, and year 3) for the Math group. The between subjects effects for average gain was significant F (2, 460) = 13.651, $p < .001$, suggesting a difference among groups. A

Scheffe Post hoc test revealed that for Math, year 1 (*M* = 0.38, *SD* = 0.14) had a larger mean on average gain than year 3 (*M* = 0.26, *SD* = 0.16); and that year 2 (*M* = 0.38, *SD* = 0.16) had a larger mean on average gain as compare to year 3 *(M* = 0.26, *SD* = 0.16); therefore, the null hypothesis is rejected. Year 1 had a lower change score than years 2 and 3. Year 3 had a lower change score than years 1 and 2. The difference between the means of year 1 and year 2 was not statistically significant and the null hypothesis is accepted. The ANOVA is are presented in Table 15 and the means and standard deviations on average gain by year (year 1, year 2, and year 3) for Math and Science are summarized in Table 17.

Table 15

Analysis of Variance for Math, Average Gain by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	13.651	0.001	0.056	0.998
Error	460	(0.022)			

Note. Number in parenthesis represents mean square error.

Research Question 3b

To examine research question 3b, an Analysis of Variance (ANOVA) was conducted to assess if there were mean differences in average gain by year (Year 1, Year 2, and Year 3) for the Science group. The between subjects effects for average gain was significant F (2, 448) = 11.646, p < .001, suggesting a difference among groups. A Scheffe Post hoc test revealed that for Science, Year 2 (*M* = 0.36, *SD* = 0.15) had a larger mean on average gain than Year 1 (*M* = 0.29, *SD* = 0.11) and Year 3 (*M* = 0.30, *SD* = 0.14); therefore, the null hypothesis is rejected. Year 1 had a lower change score than years 2 and 3. The difference between the Year 1 and Year 3 means was not significant and the null hypothesis is accepted. The ANOVA are presented in Table 16 and the means and standard deviations on average gain by year (year 1, year 2, and year 3) for Math and Science are summarized in Table 17.

Table 16

Analysis of Variance for Science, Average Gain by Year (Year 1, Year 2, and Year 3)

Variable and source	*df*	*F*	Sig.	Eta^2	Power
Year	2	11.646	0.001	0.049	0.994
Error	448	(0.017)			

Note. Number in parenthesis represents mean square error.

Table 17

Means and Standard Deviations on Average Gain by Year (Year 1, Year 2, and Year 3) for Math and Science.

	Math			Science		
Year	*N*	*M*	*SD*	*N*	*M*	*SD*
Year 1	252	0.38	0.14	205	0.29	0.11
Year 2	160	0.38	0.16	128	0.36	0.15
Year 3	151	0.26	0.16	118	0.30	0.14

Table 18

A Summary of Hypotheses/Null Hypotheses Acceptance or Rejection by Research Question and Subparts

RQ1a (MATH YEAR 1)	Are there differences in change scores among the (3) 9-week grading periods?	Null Hypothesis Rejected
RQ1b (MATH YEAR 2)	Are there differences in change scores among the (3) 9-week grading periods?	Null Hypothesis Rejected
RQ1c (MATH YEAR 3)	Are there differences in change scores among the (3) 9-week grading periods?	Null Hypothesis Rejected
RQ1d (SCIENCE YEAR 1)	Are there differences in change scores among the (3) 9-week grading periods?	Null Hypothesis Rejected
RQ1e (SCIENCE YEAR 2)	Are there differences in change scores among the (3) 9-week grading periods?	Null Hypothesis Rejected
RQ1f (SCIENCE YEAR 3)	Are there differences in change scores among the (3) 9-week grading periods?	Null Hypothesis Rejected
RQ2a (MATH 1st 9-weeks)	Are there differences in the 1st 9-week change scores	Null Hypothesis Rejected

	among years 1, 2, and 3?	
RQ2b (MATH 2nd 9-weeks)	Are there differences in the 2nd 9-week change scores among years 1, 2, and 3?	Null Hypothesis Rejected
RQ2c (MATH 3rd 9-weeks)	Are there differences in the 3rd 9-week change scores among years 1, 2, and 3?	Null Hypothesis Rejected
RQ2d (SCIENCE 1st 9-weeks)	Are there differences in the 1st 9-week change scores among years 1, 2, and 3?	Null Hypothesis Rejected
RQ2e (SCIENCE 2nd 9-weeks)	Are there differences in the 2nd 9-week change scores among years 1, 2, and 3?	Null Hypothesis Rejected
RQ2f (SCIENCE 3rd 9-weeks)	Are there differences in the 3rd 9-week change scores among years 1, 2, and 3?	Null Hypothesis Rejected
RQ3a (MATH)	Are there differences among the average gain across years 1, 2, and 3?	Null Hypothesis Rejected
RQ3b (SCIENCE)	Are there differences among the average gain across years 1, 2, and 3?	Null Hypothesis Rejected

Chapter 5

Conclusions, Summary, Discussion, and Recommendations

This chapter provides a summary of the conclusions, and a discussion of the findings related to the study. In addition, recommendations are provided for further research in the area.

Conclusions

Title IIB Mathematics and Science Partnerships (MSPs) are the main resource in the *No Child Left Behind Act* to support the ongoing professional development of science and mathematics teachers. Funds available to states must be used to purchase high-quality professional development. In addition, with increasing concerns about accountability throughout the field—from federal agencies to the individual classroom teacher and student—educational interventions must demonstrate a positive impact on important educational outcomes. The Title IIB MSPs are intended to positively affect content knowledge and pedagogical skills for mathematics and science teachers. The ultimate goal is improved student achievement in mathematics and science.

The purpose of this quantitative descriptive research study was to determine the effectiveness of a Title II mathematics and science partnership grant of 3rd grade student achievement. Specifically, this study compared the formative assessments results of twenty 3rd grade teachers' students' scores over a three year period. Students were administered a pre and post test formative assessment every 9-weeks. Since the teachers had different students every year of the study, repeated measures on an analysis of variance were conducted to assess whether there were mean differences among the change scores in each year. This analysis then was expanded to analyze each 9-week interval over the three year period and then finally, the analyses evaluated holistically the three years of data in a year to year comparison. The research questions sought to reveal if student achievement improved as the teachers progressed through the one year mathematics and science integration professional development.

Summary of Results

The descriptive statistics included the frequencies and percentages, as well as the means and standard deviations. For categorical or nominal data, frequencies and percentages were conducted. Frequency is the number of participants that fit into a certain category; it was also beneficial to know the percent of the sample that coincided with that category. Means and standard deviations were carried out on interval/ratio data. The arithmetic mean of the variables was defined as the sum of the scores divided by the number of scores. Standard deviation measured the spread of values in a set of data, otherwise known as the statistical dispersion. If the data points all were valued close to the mean value, then the standard deviation was close to zero, as it did not deviate much from the norm. To examine the research questions, repeated measures of Analysis of Variances (ANOVAs) were conducted to assess if there were mean differences among the three change scores [change 1(1st nine weeks), change 2(2nd nine weeks), and change 3(3rd nine weeks)] for math and science in year 1, year 2, and year 3.

The data reflects a change in mean scores when only the 9-week periods were compared in math and science--when viewed independent from other years. The change indicates as the academic year progressed in all three years, student achievement dipped from 9-week one to 9-week two in five out of the six segments measured. Eventually, the third 9-week segments exhibited an improvement in scores in four out of the six 3rd 9-week segments. When 9-week segments were analyzed as segments without relation to year, similar results occurred in that two out of the six segments measured reflected a decrease in achievement levels.

When the average gain was measured across years 1, 2, and 3 (RQ3); both mathematics and science achievement levels saw an increase from year 1 to year 2 then a decline from year 2 to year 3. In mathematics, year 3's final mean change reflects a lower level of achievement from the baseline year 1. Science achievement scores, on the other hand, did recover from year 2 to reflect a nominal gain from year 1 to year 3.

Because the data reflects a regression in both content areas, several questions are raised. As a former teacher and building-level school administrator, the researcher often witnessed a drop-off in teacher engagement and application when new programs were implemented. Teachers are barraged with countless canned programs, gimmicks, and enrichment programs that attempt to bolster instructional skills and student achievement. Too often, administrators do not inspect what they expect from teachers and these programs begin to flounder shortly after implementation. As evidenced by this study, student achievement improved during the year that the teachers were progressing through the grant's professional learning sequence. However, math achievement suffered during the third year or application year and science regressed to baseline levels. Did teachers become apathetic towards the content development they were exposed to? Did they return to the status quo and to their more familiar teaching styles?

When the researcher questioned several teachers regarding their apparent regression in achievement levels, most cited that they felt a sense of disconnect from the university instructor who conducted the professional learning component. This does not explain why the teachers' students' achievement levels regressed. Also, teachers expressed that the content knowledge gained during the year's worth of integration training was beneficial. If it was truly perceived as beneficial by the teachers, where then does the drop in achievement come from?

School administrators are charged with many tasks to effectively manage a school but at the top of the list should be instructional leadership. Administrators must ensure that programs and interventions designed to raise student achievement and develop quality teachers should garner a majority of their instructional focus (Garet, Porter, Desimone, Birman, & Yoon, 2001). Sadly, administrators are oftentimes pulled from classroom observations and collegial development opportunities to deal with a host of non-instructional challenges that arise throughout the day (Desimone, Porter, Garet, Yoon, & Birman, 2002).

Edith Gummer and Jennifer Stepanek (2007) conducted a study that described the nature of the funded professional development activities in the Title IIB MSP projects in the Northwest Region of the Unites States and characterized the models of evaluation during their first year of implementation, 2004–05. The analysis was structured around the factors of professional development that have been identified as associated with changes in teacher knowledge and practice (Desimone et al., 2002; Garet, Birman et al., 1999; Garet, Porter et al., 2001; Porter et al., 2000). The description of the evaluations examined the extent to which the projects connected their activities to measurable outcomes for teacher knowledge and practice and for student achievement, measured those outcomes, and clearly articulated their qualitative and quantitative study designs.

The prevalent model of professional development in the MSP projects studied by Gummar & Stepanek (2007) were two-week, content-focused workshops or institutes held during the summer, with follow-up support for teachers during the school year. The model studied reflected the prevalence of the institute model in the previously funded Eisenhower Professional development Program mentioned in Chapter 2 of this study.

This study focused upon measuring student achievement levels of students, whereas the Gummer & Stepanek (2007) study sought to evaluate the professional development effectiveness of the MSP content development component of the Title IIB grant. Evaluations of the Northwest Region projects relied on capturing participant reactions and self-reporting as the only sources of evidence of their effectiveness. Few projects used well developed instruments to measure changes in teacher content knowl-edge. Projects indicated difficulties using state assessments to directly measure the impact of projects on student achievement (Gummer & Stepanek, 2007). This is why formative assessments were used in this study as opposed to state summative criterion-referenced assessments. This researcher felt that the formative assessments results could provide a more informative glimpse at the MSP effectiveness with quantifiable data.

Implications

For all the school districts that participate in Title II math and science partnership grants; administrators, teachers, and other stakeholders want to know if the funds appropriated for mathematics and science professional learning and integration are beneficial towards student achievement. As the year 2014 approaches and the required annual measureable objectives (AMOs) reach 100% as required by NCLB, mathematics achievement will prove to be pivotal for LEA’s to make adequate yearly progress (AYP).

The importance of effective mathematics and science integration also continues to express itself as the United States appears to fall behind other industrialized countries in technological development and innovation.

Quality professional learning often means sustainability. For the new program, methodology, or skill set to become learned and applied behavior, it takes longer than one year. Title II will continue to fund these grants but answers must be found to address how achievement levels can not only be increased but more importantly maintained.

As stated in Chapter 2 of the literature review, the nature of the professional development being implemented in Georgia MSP projects is examined using an analytic framework based on the National Evaluation of the Eisenhower Professional development Program (Desimone et al., 2002; Garet, Birman et al., 1999; Garet, Porter et al., 2001; Porter et al., 2000). The framework is organized around six features of high quality professional development that were identified in that evaluation of mathematics and science programs: duration, activity type, collective participation, content focus, active learning, and coherence. The Eisenhower framework is one of many possible strategies with which to analyze and describe professional development. A range of alternative frameworks were considered for use in the descriptive analysis (American Federation of Teachers, 2002; Loucks-Horsley et al., 1998; National Staff Development Council, 2001). The Eisenhower framework was selected because it is grounded in existing research and was tentatively validated with self-report data from teachers, it is widely known in the field, and it is specifically related to the content areas of mathematics and science. The Eisenhower criteria are reflected in the definition of professional development put forth in the *No Child Left Behind Act*, which provides guidelines for designing projects such as the Mathematics and Science Partnerships. Some of the parameters of the definition include a focus on teachers' knowledge of academic subjects, skills to help students meet challenging standards, and understanding of effective instructional strategies that are grounded in scientifically based research. The definition establishes that professional development must be connected to school and district improvement plans and aligned with standards, curricula, and assessments. Another emphasis is on activities that are sustained, intensive, and classroom-focused rather than short-term workshops or conferences.

Title IIB math and science partnership grants also attempt to close the gap in technological innovations advances between rival first-world countries. If the United States wants to declare itself a leader in technology, it must begin to look beyond Eisenhower-era funding models and embrace more results-oriented models. For example, school systems and states might receive block grants or categorical grants only after achievement sustainability is proven. As a country, the Unites States cannot continue to simply fund programs that do not provide a long lasting and quantifiable pattern of results.

Limitations of the Study

One limitation of the study was the small number of teachers' data examined. Only twenty teachers were used in the study and they were all 3rd grade teachers. Gummer & Stepanek (2007) found in their comprehensive study of MSP effectiveness that the professional development might include a majority of teachers who were teaching at a level different from that targeted by the state science assessment. Also, they discovered that a lack of instruments for measuring changes in teacher and student knowledge of specific content led some projects to attempt to develop their own measures, while other projects resorted to less rigorous methods. Since this study focused upon only one grade level and in only one state, the Georgia Performance Standards were in fact the only standards taught.

Clearly, more students and more data sets could be incorporated in a study along with multiple grade levels. Moreover, all of the teachers are employed within the same school district in north Georgia so there are geographical and socioeconomic limitations to the sample population and professional learning experience for the teachers involved. For example, there are no African-American students in this school system so there is a large ethnic demographic not even represented in the findings. Since these grants are also awarded to several states, a multi state study might prove insightful. The quality of the university instructors could vary greatly from school district to district, regionally, or as in the case of this study, an almost rural isolationist attitude seemed present with teachers. They felt they could not effectively relate to their university instructor who was from a nearby large metropolitan area.

Only teachers who volunteered to participate in the math and science partnership were studied. In fact, participation in the grant was voluntary. Since all teacher participants had experience levels lower than 15 years, veteran teachers and their more mastered teaching styles were not expressed in this study. New teachers would approach a professional learning opportunity differently than a master teacher, especially in the field of content development. A master teacher might feel almost insulted that someone is proposing that they can be taught new and innovative instructional strategies and content. Conversely, new teachers are more often than not eager to develop their instructional skill set and are more open minded to new ideas (Gummer & Stepanek, 2007). In this study, several of the teachers were mid-level instructors, those with experience levels from 6-15 years. These teachers often grow weary of new programs or professional learning activities designed to build teacher efficacy. Experience tells this researcher that interestingly enough, this is also the experience level that sees the most teachers leave the teaching profession. There is a fine line between acceptance and apathy and this study was surely limited not only by the small number of teachers studied but also by the limited number of veteran teachers who participated in the grant.

Recommendations for Future Practice

The purpose of the study was to determine if the Title IIB mathematics and science partnership grant was effective in improving student achievement. Local education agencies should still compete for and acquire these grants. Districts should also focus on monitoring the implementation of the math and science strategies and best practices taught during the year of professional learning and development. It is clear that there was a drop-off in student achievement levels in the year after teachers participated in the training. Whether there was insufficient instructional leadership provided by administrators, pressure for teachers to outpace instructional pacing guides, or teachers simply regressed back into their normal teaching style and modality remains to be determined. Administrators should monitor teachers and if the time and monetary commitment needed to complete the mathematics and science partnership was not enough to warrant diligence from administrators then it is a poor reflection on our present level of instructional accountability.

Recommendations for Future Research

The current study is significant because it attempted to determine the effectiveness of a program that targets not only teacher professional development but also, the program attempts to increase student achievement and bolster our society's competiveness in an ever-shrinking global community where technology, science, and mathematics have become the new currency of knowledge. Future research should incorporate more grade levels, a multitude of school districts that can reflect a variety of socioeconomic and various demographic populations.

The study was limited also because all of the participants experienced the same level and quality of math and science integration professional development. In the future, different districts could be compared, or a larger span of grades—although higher secondary grade levels tend to polarize and teachers tend to specialize in only math or science education.

A qualitative study might focus upon the teachers' application of knowledge learned, their motivation and morale towards implementing the integration strategies, or possibly the adult learning styles of the teachers.

As school systems, legislators, administrators, and parents seek to provide the most meaningful and appropriate educational setting for children, the bottom-line is never far behind. The public funding of education necessitates accountability for the resources expended and Title II MSPs, along with other government funding, will continually be evaluated and the effectiveness will be questioned as achievement goals continue to rise and the theoretical dissolution of the learning bell curve is magically negated by 2014.

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Appendix A

Georgia Department of Education

Division of Curriculum and Instructional Services

GEORGIA DEPARTMENT OF EDUCATION

Mathematics and Science Partnership (MSP) Program

Request for Proposals (RFP)
2009-2011

Local Competitive Grant – Title II Part B

RFP Published: November 14, 2008

Proposals Due: February 3, 2009 by 4:00 p.m.

Grant Award Notification: April 30, 2009

Program Dates: Fiscal Years 2010 and 2011

Georgia Mathematics and Science Partnership (MSP) Program Abstract

Objective: The purpose of the Georgia Mathematics and Science Partnership (MSP) Program is to improve the content knowledge and ability to analyze student thinking of cohort groups of mathematics and/or science teachers of grades 3-5, 6-8, and/or 9-12 in order to increase the achievement of their students. These improvement efforts are designed, implemented, and evaluated by strong partnerships between college and university faculty, high-need school systems, and other qualifying partners.

Eligibility: An eligible partnership is one that demonstrates deep and mutual engagement between (a) one or more school systems, at least one of which must meet high-need criteria; and (b) science, technology, engineering, and/or mathematics (STEM) faculty and faculty from the unit responsible for the preparation of teachers (typically the college of education) at an accredited 2 or 4 year college or university. It may also include additional accredited colleges or universities as well as non-profit and for-profit organizations with proven effectiveness in providing professional development to teachers of mathematics and science. In order to qualify as high-need, a school system must demonstrate that at least 25% of its students qualify for the free and reduced meal plan.

Priorities of the GaDOE: In addition to the objective and partnership eligibility descriptions listed above, the Georgia Department of Education (GaDOE) places funding priority on partnerships that
(a) recruit, serve, and retain teacher cohort groups from schools with the greatest academic or instructional need; (b) produce a cohort group of grades 3-5 teachers with certification endorsements in mathematics and/or science; (c) serve teachers who will be teaching Mathematics I and II; and (d) show evidence of ways in which building-level administrators will meaningfully participate in the partnership's follow-up professional learning sessions.

Amount to be Awarded: $5,285,439

Maximum Award Value: $450,000/partnership
Historically, the average award amount has been approximately $200,000.

Anticipated Number of Awards: 20-30

Award Distribution: The GaDOE intends to fund MSP projects equitably and to distribute the projects across the state to the extent that submitted, qualified proposals allow.

Duration of Grants: July 1, 2009 – June 30, 2011, pending (a) evidence of project effectiveness, (b) compliance to program requirements, and (c) availability of federal funding

Fiscal Agents: Fiscal responsibility for the grant may rest with either the lead school system/RESA partner or the lead higher education partner, as determined by which has greater capacity to serve in that role.

Intent to Apply: Applicants should submit a non-binding notice of Intent to Apply via email to

Amanda Buice (abuice@doe.k12.ga.us), MSP Program manager, by Tuesday, December 16, 2008. These intention letters will help the GaDOE make appropriate appointments to the grant review panel.

Review and Notification of Awards: It is the intention of the GaDOE to convene an expert review panel in February and present funding recommendations to the State Board of Education at its April 2009 meeting. Therefore, the GaDOE anticipates announcing award decisions to partnerships by the end of April 2009.

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Mathematics and Science Partnership (MSP) Program Overview

Title II Part B: Mathematics and Science Partnership (MSP) Program Overview

The Mathematics and Science Partnership (MSP) Program is funded under Title II, Part B of the *No Child Left Behind Act of 2001*. Its purpose is to improve the content knowledge and teaching skills of mathematics and/or science teachers in order to increase the achievement of their students. Strong partnerships between (a) qualifying high-need school systems, (b) science, technology, engineering, and mathematics (STEM) faculty, and (c) faculty from the unit responsible for the preparation of teachers in institutions of higher education are at the core of these improvement efforts. Such partnerships assume responsibility for designing, implementing, and evaluating professional learning programs that effect deep, lasting improvement in mathematics and science education through three broad means:

a) providing opportunities for **enhanced and ongoing** professional learning of mathematics and science teachers that improves their content knowledge and instructional practice;
b) using **scientifically-based researched teaching methods** to promote strong teaching skills for mathematics and science teachers; and
c) establishing and operating intensive mathematics and science institutes for teachers with follow-up training and support.

The goals of the federal MSP Program include (a) increasing the number of mathematics and science teachers who participate in content-based professional development; (b) increasing the number of highly qualified mathematics and science teachers; and (c) improving the mathematics and science achievement of students of participating MSP projects.

Georgia's MSP Program Description and Goals

Title II, Part B of the *No Child Left Behind* legislation authorizes each state to conduct an MSP competitive grant program. The Georgia Department of Education (GaDOE) is responsible for administering the program and is authorized to award $5,285,439 in competitive grants as of July 1, 2009. Grants will be awarded to eligible partnerships for a period of two years, subject to (a) compliance with program requirements, (b) demonstration of effectiveness, and (c) availability of federal funding.

As the Georgia Performance Standards (GPS) and state assessments to measure student progress are implemented, school systems are concentrating their efforts on adjusting instruction to prepare greater numbers of students for high achievement in mathematics and science. To support these improvement efforts, the Georgia MSP Program strives to improve grades 3-12 mathematics and science teacher quality by immersing teacher cohort groups in sustained, creative, and strategic professional learning that **extends beyond commonplace approaches** to improve mathematics and science achievement. This cohort-based approach will enable teachers to see themselves as integral members of a professional community linked with others devoted to learning and practice.

The Georgia MSP Program seeks to improve the content knowledge and ability to analyze student thinking of mathematics and science teachers in grade 3-5, 6-8, and 9-12. More specifically, the program strives to meet the following goals:

- Increase the capacity of grades 3-5, 6-8, and/or 9-12 mathematics and/or science teachers to improve student achievement as measured by state assessments, particularly in schools with the greatest instructional and academic need;
- Increase the number of grades 3-5, 6-8, and/or 9-12 mathematics and science teachers who participate in content-based professional learning and who are prepared to teach challenging courses and curricula;
- Increase the number of grades 3-5 teachers with certification endorsements in mathematics and/or science; and
- Increase the number of building-level administrators who participate meaningfully in follow-up mathematics and/or science professional learning sessions of MSP projects.

The GaDOE anticipates funding 20-30 projects showing the potential to accomplish these goals and will distribute the awards to projects across the state to the extent that submitted, qualified proposals allow.

Georgia MSP Program Requirements and Administration Information

To increase the likelihood of reaching these goals, the GaDOE has set specific requirements for partnerships in terms of high-need criteria, partnership eligibility, use of funds, allowable expenditures, and the anticipated grant competition timeline.

<u>High-Need Criteria</u>
A school system is considered to be high-need by the Georgia MSP Program if it meets the following criterion:

- At least 25% of its students qualify for the free and reduced meal program as determined by the most recent data collected by the GaDOE (See appendix B).

<u>Eligible Partnerships</u>
Partnership is critical to the success of individual MSP projects. Partnerships eligible to apply for an MSP Program grant ***<u>must</u>*** include:

- at least one high-need school system;
- the science, technology, engineering, or math (STEM) department of an accredited 2 or 4 year college or university; **<u>and</u>**
- the teacher preparation unit of an accredited 2 or 4 year college or university.

Partnerships ***<u>may</u>*** also include:

- one or more school systems that may or may not qualify as high-need;
- the STEM department of another accredited 2 or 4 year college or university;
- the teacher preparation unit of another accredited 2 or 4 year college or university;
- public charter and magnet schools, private elementary or secondary schools, or a consortium of such schools;
- a non-profit or for-profit organization with demonstrated effectiveness in improving the quality of mathematics and/or science teachers.

<u>Partnership Roles</u>

Partnerships must have a management structure in which each partner is <u>fully</u> represented and engaged, including a project director from the organization serving as fiscal agent as well as project leaders from each of the remaining organizations. In addition, it is recommended that one teacher from each participating school/system serve on the management team. This project management team must meet regularly to oversee all phases of the project, including design of the project, recruitment and retention of the teacher cohort group, implementation of the project plan, and collection and analysis of data related to its impact on teaching and learning. Additionally, the project management team has collective program responsibilities:

- Submit a mid-year performance report to the MSP Program manager at the GaDOE;
- Submit an annual performance report to the U.S. Department of Education (USDE) and GaDOE within 60 days of the conclusion of each project year;
- Participate in regional conferences and institutes (1-2 per year) organized by USDE; and
- Participate in bi-monthly conference calls and semi-annual MSP Program leadership team work sessions facilitated by the GaDOE program manager.

At the conclusion of project year one, the management team will submit a brief application to the GaDOE that must include compelling justification for funding to be continued into project year two.

During the grant period, a site visit(s) from the MSP Program manager of the GaDOE should be expected. It is the responsibility of the management team, particularly the project director, to ensure that the MSP Program manager is kept current as to when and where the professional learning sessions will take place.

<u>Partner Organization Proposal Limit</u>
For this competition, an organization may submit only one proposal as the <u>lead</u> partner of an MSP project. That organization may be included as a secondary partner on proposals by other partnerships that do not seek to provide professional learning opportunities in the grade levels and content area(s) already provided for by said organization.

<u>Fiscal Responsibilities</u>
The GaDOE has determined that either the lead school system/RESA partner or the lead higher education partner may serve as the fiscal agent of the grant. Fiscal agency should be determined according to which organization has the greater capacity to serve in such a role. Indirect funds to this agency may not exceed 8% for its role as fiscal agent. The remaining partner organizations may charge up to 5% of their total request in indirect costs to the grant. ***The grantee is subject to the audit requirement contained in the Single Audit Act Amendments of 1996 and revised OMB Circular A-133. Non-profits must comply with OCGA 50-20-2 for auditing and financial information submission. The grantee is subject to financial compliance monitoring from GaDOE, USDE or other designated by GaDOE to conduct monitoring.***

<u>Uses of Funds</u>
A partnership may use MSP Program funds for one or more of the following initiatives for mathematics and/or science teachers of grades 3-12:

- Creating opportunities for enhanced and ongoing professional learning that improves their content knowledge and ability to analyze student thinking and make corresponding instructional decisions;
- Establishing and operating mathematics and/or science intensive institutes and related follow-up training and support that (a) directly relate to the curriculum and content in which the teachers provide instruction; (b) improve the ability of the teachers to

understand and use the Georgia Performance Standards (GPS) in mathematics and/or science; (c) improve the ability of teachers to integrate and to understand applications of the STEM disciplines; (d) provide instruction and practice in the effective use of content-specific pedagogical strategies; and (e) provide instruction in the use of data and assessments to inform mathematics and science classroom practice.

Allowable Expenditures

Georgia MSP Program funds must be spent exclusively on costs associated with providing high quality, content-specific professional learning opportunities to mathematics and/or science teachers of grades
3-12. In general, it is expected that MSP partnerships will spend approximately $30-$40 per teacher per contact hour on the total cost of their MSP Program work. The following table provides further specificity to allowable expenses.

Category	**Guidelines**
Teacher Stipends	Not to exceed $150 per 8-hour day during off-contract time; teacher fringe benefits may be covered by MSP grant funds. Teachers must be eligible to work in the United States.
Substitutes	Up to $100/day when MSP training sessions take place during teacher contract time
Project Management Team Salaries	Not to exceed 10% of the project director's salary and 5% of project leaders' salaries Teachers serving on the management team may be paid an honorarium at the same rate allowable for teacher stipends.
School-Based Coaches' Salaries	Not to exceed 35% of an instructional coach's salary
Consultants and Contracts	Not to exceed $50/presentation hour and $25/planning and preparation time for consultants or presenters; not to exceed $35/presentation hour and $17.50/planning and preparation time for system/RESA personnel
Higher Education Faculty	Regular salary per hour of contact time; 50% of salary per hour of planning/preparation time
Evaluation	8%-10% of total project budget **must** be spent on a formal project evaluator. GaDOE will allow an additional $5,000 for a quasi-experimental design payable at the end of the project.*
Travel	Reimburse mileage, meals, and lodging according to state/system guidelines for project-related travel
Meals	Not to exceed 1% of the total budget. Must be in accordance with OCGA 50-5B-5 and federal guidelines. Guidelines will be shared upon receiving a MSP grant award.
Management Team Events	Reimburse travel expenses for management team participation in USDE and GaDOE-hosted MSP events according to state/system guidelines.
Materials and Supplies	Funds may be spent on materials and supplies to facilitate professional learning of teachers, not on classroom instructional materials.
Indirect Costs	Not to exceed 8%

Additionally, MSP Program funds **cannot** be spent on equipment (e.g. smart boards, computers, printers, camcorders, etc.), capital improvements, facility rentals, administrative or clerical personnel, full salaries, or room and board**. Instructional materials can only be purchased for the teacher attending the professional development for the purposes of the program (federal funds may not be used to purchase equipment or instructional materials for the students of the teacher).**

MSP Program funds received must be used to supplement and not to supplant funds that would otherwise be used to support proposed activities.

*Quasi-experimental Study - A rubric is being designed by the USDE to determine whether a grantee's evaluation meets the minimum criteria that need to be met for an evaluation to have been successfully conducted and yield valid data. Evaluation components covered in the rubric include sample size, quality of measurement instruments, quality of data collection methods, data reduction rates, relevant statistics reported, and baseline equivalence of groups. The rubric will be posted at www.ed-msp.net under "Resources."

Anticipated Grant Competition Timeline

The GaDOE expects to adhere to the following timeline with respect to the MSP grant competition but reserves the right to make changes as necessary.

Request for Proposals (RFP) Posted	November 14, 2008
Technical Assistance Elluminate Sessions:	
Part1 – Understanding GA MSP, Partnerships, and Needs Assessment	November 17, 2008
Part 2 – Work Plan, Assessment, Budget	November 19, 2008
Technical Assistance Workshops:	
Kennesaw Center/Kennesaw (Room 300)	December 2, 2008
Cunningham Center/Columbus (Blanchard Hall A)	December 4, 2008
Classic Center/Athens (Parthenon Room)	December 9, 2008
Coastal Georgia Center/Savannah (Room 111)	December 11, 2008