MIX IT UP

PROGRAM EVALUATION OF TEACHER

PROFESSIONAL DEVELOPMENT

CORRELATED SPACE SCIENCE AND GEOLOGY AND MATHEMATICS

THESIS

Presented to the Graduate Council of
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Master of SCIENCE

by

Melissa A. Duran , B.S.

San Marcos, Texas
December, 2010

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DEDICATION PAGE

I would like to dedicate this thesis to my nephew SSGT Mark Juarez, who was injured in Afghanistan on September 11, 2010 in service of our country. His continued strength and perseverance through his rehabilitation has inspired the completion of this thesis.

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ABSTRACT

MIX IT UP

PROGRAM EVALUATION OF PROFESSIONAL DEVELOPMENT

CORRELATED SPACE SCIENCE AND GEOLOGY AND MATHEMATICS

By

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December 2010

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This study is based on the new model of linking science and mathematics called *Correlated Science and Mathematics* (*CSM*) in two science led courses, Correlated Geology and Mathematics and Correlated Space Science and Mathematics. The model is unique in that it links mathematics and science thoroughly with seven fundamental goals:

(1) teaching for conceptual understanding; (2) using each discipline's proper language; (3) making the natural links between the disciplines; (4) identifying language that is confusing to students; (5) using standards-based learning objectives; (6) identifying the parallel ideas between the disciplines when possible; and (7) using a 5E inquiry format for science and mathematics when appropriate. The study utilized a mixed-method research design which has components of both qualitative and quantitative instruments and was used to evaluate the research questions framing this study. The professional development took place during the summer of 2008, and consisted of 10 mathematics and science teacher teams. The data consisted of teachers' demographics including analysis of transcripts, certification and current teaching assignment, pre and post tests results, structured principal and teacher interviews, classroom observations, as well as, student reflections, student pre and post testss and TAKS scores. The data analysis indicates that the teachers significantly increased their content knowledge in space science and geology. However, the science and mathematics teachers did not significantly improve their mathematics content knowledge. Overall, teachers improved their understanding of the CSM Model and adapted an integrated approach to mathematics and science in their classroom, and improved their instructional skills such as inquiry, and mathematics and science manipulatives. The student descriptive data analysis suggests that one 7^{th} grade mathematics class and one 8^{th} grade science had significant improvement on the student pre and post tests. Remaining science and mathematics classes showed positive trends but no significant improvement.

CHAPTER I

INTRODUCTION

Mix It Up: Correlated Science and Math (CSM) Teacher Preparation and Professional Development Program Overview

This study is a continuation of the *MIX IT UP* Teacher Professional Development Program which began during the summer of 2006. The program is a professional development program for preservice and inservice middle school science and mathematics teachers (West, Vasquez-Mireles, & Coker, 2006). Co-developed by Dr. Sandra West and Dr. Selina Vasquez-Mireles and implemented at Texas State University-San Marcos, the program was designed to enhance the teachers' conceptual understanding of science and mathematics content and content pedagogy and enhance the academic performance of their students in science and mathematics.

Rational of the Study

Many reasons have been put forth for the reform of instructional strategies to include integration of science and mathematics. Integration is not simply using new teaching strategies in the classroom. It involves conceptual understanding of both disciplines by the teachers (Pang & Good, 2000). Teachers need to understand the effect integration has on the conceptual learning of the students for integration to move into the classroom (Pang & Good, 2000). There is an abundant amount of literature that supports and identifies ways to integrate mathematics and science. Despite strong support from NCTM (2000) and NRC (1996), limited amounts of research link student achievement to the integration of mathematics and science (Huffman, Thomas, & Lawrenz, 2003). No studies report an improvement in students' science scores and only two studies report an improvement in students' mathematics scores (Judson & Sawada, 2000; Yasar, Little, Tuzun, & Rajesethuathy, 2006).

Research Questions

In order to evaluate the successfulness of the CSM program, four questions were asked.

1. As a result of participating in the professional development program, did teachers' content knowledge and skills increase in space science, geology, and mathematics?
2. To what extent did teachers implement integrated science and mathematics lessons?
3. To what extent did the *Mix It Up* Professional Development improve the instructional skills of the middle school science and mathematics participants by modeling the use of research-based best practices?
4. Did student achievement increase in science and mathematics?

CHAPTER II

LITERATURE REVIEW

STEM Education

According to the National Center for Education Statistics, there is rising concern about America's ability to maintain its competitive position in the global economy (National Center for Education Statistics, 2009). Consequently, there is a renewed interest in Science, Technology Engineering, and Mathematics (STEM) education. Three prominent U.S. scientific groups, the National Academy of Science, the National Academy of Engineering, and the Institute of Medicine jointly issued a report which called for strengthening the STEM education from primary through postsecondary education (The National Academy of Science, 2005). Their report recommends increasing investment in STEM programs, enhancing the STEM teaching force, and enlarging the pool of students pursuing degrees and careers in STEM fields. Additional research should focus more on; (1) what are the various characteristics of students entering STEM fields of study?; (2) the expected educational outcomes of those entering STEM fields of study (degree completion) and; (3) the completion rate of students entering a STEM field of study.

Trends in Mathematics and Science Education

Nationally representative data on student achievement come primarily from two sources: the National Assessment of Educational Progress (NAEP) and the United

States' participation in international assessments: Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) (NCES, 2009). The NAEP measures fourth, eighth, and twelfth grade students' performance in mathematics and science, as well as other subjects. This assessment is designed specifically for national and state information needs. The International assessments, PISA and TIMSS, enable the U.S. to benchmark itself in categories such as fourth and eighth grade mathematics and science in the TIMSS. PISA assesses 15-year-old students' mathematics, science, and reading literacy. All of these assessments are conducted regularly to allow the monitoring of student outcomes over time (NCES, 2009).

Mathematics

Recent results from TIMSS and NAEP show trends in student performance in both fourth and eighth grade mathematics. The time interval for data collection for both the NAEP and the TIMSS is similar with the NAEP showing trends between 1996 and 2007, while TIMSS presents trends between 1995 and 2007. Both assessments, have shown significant increases in the mathematics performance for both fourth and eighth grade U.S. students. The NAEP reported increases in each of the four ethnicities: Non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic Asian/Pacific Islander, students at the top and bottom of the distribution, as well as for students receiving free and reduced-price lunch at both grades. In contrast, TIMSS detected only increases in mathematics performance for White and Black students in both grades and students within the 10^{th} percentile in both grades while no change was detected for students receiving free and reduced price lunch. However, according to NCES (2009), the NAEP assessment, in contrast to TIMSS, may have detected small changes among nationally relevant subgroups which may be due to NAEP's larger sample size. The TIMSS is designed to detect differences among the countries and, therefore, there is a smaller sample size from each country.

Comparing the results from NAEP and PISA in mathematics and science at the upper grades is more difficult than comparing NAEP and TIMSS for the following reasons. Not only are the populations and frameworks different, but PISA has not yet reported a trend in science and is reporting data for only a three year difference (2003 to 2006) for mathematics (NCES, 2009). PISA did not show any differences in mathematics performance of U.S. 15 year olds between 2003 and 2006 (NCES, 2009).

Science

Results from the NAEP and the TIMSS show similar trends for fourth and eighth grade science, but over a slightly different time period. The NAEP covers a time interval between 1996 and 2005, whereas the TIMSS shows trends from 1995 and 2007. These trends are less consistent than the math results perhaps the time periods in science are less consistent than the time period for mathematics (NCES, 2009). The NAEP showed an increase in fourth grade students' science performance overall between 1996 and 2005; whereas TIMSS did not detect any change in performance overall between 1995 and 2007. Additionally, NAEP also reported increases in science performance for four of five racial/ethnic subgroups (White, Black, Hispanic, Asian/Pacific Islander). However, TIMSS reported increases for only Black and Asian/Pacific Islander students in the fourth grade (NCES, 2009). NAEP reported a decreased in science scores among 12th graders. The average science score was lower in 1996 and there has been no significant change in science scores since 2000. NAEP reported slight decreases in mathematics among twelfth graders from 1996 to 2000 while reporting slight increases among eighth-graders in mathematics from 1996 to 2007.

History of Science and Mathematics Integration

The demand for more integrated science and mathematics courses is a result of American students' scores on international exams (Hollenbeck, 2007). The literature on Integrating Mathematics and Science is not new and actually dates back to the early 20th Century (Berlin & White, 1999). Since the beginning of the 20th century, the integration of mathematics and science has been considered the most promising path to improving student achievement (Berlin & White, 1999). Teachers of different subjects agree that there is value in and the need for integrating subjects (National Council for the Social Studies, 1994; National Council of Teachers of English, 2000: National Council of Teachers of Mathematics, 2000; National Science Education Standards, 1995). Additionally, studies have shown that integration of mathematics and science has a positive effect on students' attitudes, participation and interest in school (Bragow, Gragow & Smith, 1995; McComas, 1993), as well as achievement (Hurley, 2001). In contrast, according to a literature review by St. Clair and Hough (1992), prior studies regarding the effectiveness of curriculum integration has not shown to be any more effective than a traditional instruction. The authors recommend additional studies, but little has been done to date.

Science and Mathematics Integration

Mathematics and science are typically viewed as logically connected (American Association for the Advancement of Science, 1990; McBride & Silverman, 1991; Pang &

Good, 2000). This bond has generated an interest in the integration of the two disciplines in classroom teaching, has appeared in the literature since the early 1900’s (Berlin & Lee, 2005). There has been an increasing interest in linking science and mathematics in the classroom since the 1970’s and escalated in the 1990’s (Berlin & Hyonyong, 2005). This was a result of a call for reform in science and mathematics education by the National Standards for Science Education (NSES, 1994), the National Council for Mathematics Teaching (NCTM, 2000), and the American Association for the Advancement of Science (AAAS, 1993). The National Science Education Standards (NRC, 1996) also emphasized the importance of connecting the study of science to other school subjects.

Huntley (1998) described several levels of integration: using the terms intradisciplinary, interdisciplinary, and integrated to represent variations of curricular organization that increase in complexity and extent of integration (Huntley, 1998). Intradisciplinary refers to a lesson that focuses on one discipline. Interdisciplinary curriculum is one in which the focus of instruction is on one discipline while another subject is used to support it. Huntley describes integration as a curriculum in which a teacher or teachers use concepts from more than one discipline during instruction. To clarify the many definitions of an integrated science and mathematics lesson, integration is often described as a continuum (Huntley, 1998; Lonning, R.A., DeFranco, T. C. & Weinland, T.P., 1998). Huntley (1998) illustrated this continuum as seen in Figure 1.

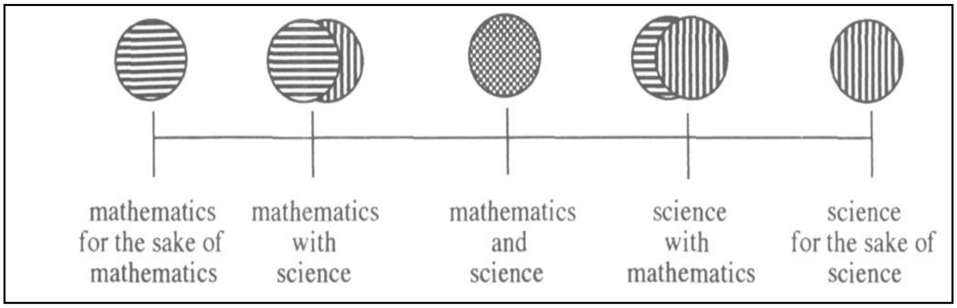

Figure 1. Continuum of Mathematics and Science Integration. Adapted from "Design and implementation of a framework for defining integrated mathematics and science education" by A. A. Huntley, 1998, *School Science and Mathematics, 98,* p. 322. Copyright 1998, by School Science and Mathematics Association.

Huntley (1998) describes a pure science lesson as one where only science is taught without any mathematics. Thus, the science only-oriented lesson would be at one end of the continuum and a mathematics only-oriented lesson without any science would fall at the opposite end of the continuum. Moving toward the middle of the continuum, science and mathematics lessons become increasingly integrated to produce a lesson that is "science with mathematics" or a lesson that is "mathematics with science." At the center of the continuum there is a union of the two disciplines where there is more than just equal treatments of both disciplines (Huntley, 1998). Each discipline has synergistic roles that enhances or magnifies the concept equally (Huntley, 1998). McBride and Silverman (1991) describe the integration of science into mathematics with science providing examples of mathematical concepts and mathematics providing a fuller understanding of science. For example, students in a mathematics class are learning how to calculate surface area of a can (rectangular prism). The teacher integrates science into mathematics by having the students heat a can with a small amount of water. The can is then removed from the heat and a lid placed on the can. As the can cools, the pressure inside the can decreases and the can is slowly crushed by the external air (McBride & Silverman, 1991). The students are challenged to see if they can determine the total surface area of the can. Additionally, they are required to compute the total air pressure on the surface to see if it would be great enough to crush the can. The mathematics lessons remain a mathematics-focused lesson with science supplying examples of mathematics usage. Science lesson remains science-focused where mathematics is used as a way to explain science concepts (Huntley, 1998). The closer to the middle of the continuum, the more indistinguishable the two disciplines become according to Huntley (1998). The point on the continuum line where there is no delineation between a science lesson and a mathematics lesson is where *true* [italics added] integration occurs, but, mathematics will still use science as an application and a science lesson will use mathematics to explain science concepts (Huntley, 1998; Roebuck & Warden, 1998; Judson & Sawada, 2000).

Huntley (1998) proposed an integrated science and mathematics lesson which purportedly blends the two lessons such that the lesson would fall in the middle of the continuum (see Figure 1). However, Huntley's example of a true integrated lesson (science and mathematics) showed a typical lesson on photosynthesis where students use mathematics to measure the surface area of a leaf to relate the relationship between surface area and photosynthesis (West & Browning, 2009). This example was, instead, a traditional integrated science with mathematics lesson where science uses mathematics as a tool to better understand a science concept.

Correlated Science and Mathematics Model (CSM)

An authentic science and mathematics model called Correlated Science and Mathematics (*CSM*), based on the initial work by West and Tooke (2001), deepens and broadens the connections between science and mathematics and deepens the conceptual understanding of both disciplines. As described by West and Browning (2009), the *CSM* model is defined by seven fundamental goals: (1) develop a conceptual understanding of mathematics and science; (2) use each discipline's proper language; (3) make the natural links between the disciplines; (4) use standards-based learning objectives; (5) identify language that is confusing to students; (6) identify the parallel ideas between the disciplines when possible; and (7) use a 5E inquiry format in science and mathematics when appropriate. Therefore, West & Browning (2009) propose this new continuum that incorporates the *CSM* model that more fully integrates the two disciplines.

The *CSM* model is used to teach science and mathematics, not science with mathematics or mathematics with science. For a lesson or course to be truly correlated all seven of the *CSM* goals must be addressed. Additionally, in the purest form of the *CSM* Model, instructional time and emphasis would be placed equally on the mathematics and science concepts and one could not easily discern whether the lesson or course has a science or mathematics focus (West & Browning, 2009).

Teacher Professional Development in Integration Mathematics and Science

Professional development is define as the "Process in which instructors acquire knowledge and skills to improve the quality of teaching for learners and, ultimately, to enhance learner outcomes" (Kutner, Sherman, Tibbetts, & Condelli, 1997). Professional development (PD) in science and mathematics education should focus on giving teachers the necessary tools for the classroom that would increase the understanding and skills of their students in science and math. Some of these tools involve improvement in teacher content area knowledge, the use of best practice teaching strategies, and the correct content pedagogy to implement these teaching strategies. Professional development should ultimately increase student achievement (Guskey & Sparks, 1996).

Presently, the United States expects schools to be held accountable for improving student achievement to adhere to state and national standards (Johnson, 2006). "Many states have aligned their standards with the National Science Education Standards (NSES) and have included standards on inquiry-based science" (Johnson, 2006). The No Child Left Behind legislation (NCLB) of 2001, requires new standards and school accountability and subsequently an outcry for more professional development programs to increase student achievement (Hollenbeck, 2007; Gusky & Sparks, 1996). Furthermore, many teachers are placed in teaching positions for which they are inadequately prepared (Loucks-Horsley & Matsumoto, 1999). The goal of professional development is to improve teacher effectiveness and student achievement. Professional development programs are criticized and are not considered a worthwhile investment unless the goal is targeted towards student achievement (Loucks-Horsley & Matumoto, 1999). However, measuring the effectiveness of PD in terms of student achievement is extremely difficult (Guskey & Sparks, 1996). The question of how to measure PD in terms of student achievement has perplexed researchers for years and has led only to an assumption that PD will improve student learning (Guskey & Sparks, 1996). Many different factors affect student achievement. While it is true that teachers are the heart of student achievement, other factors, such as quality staff development, administrators' and parents' knowledge and practices influence student achievement (Loucks-Horsely & Matsumoto, 1999). Additionally, other important factors include, poverty, ethnicity, (Berliner, 2010). In this age of accountability with held to higher standards enabling them to compete in the global market, quality PD is critical to improve student achievement (Guskey, 2002a; National Academies, 2007). Equally important is ensuring that the PD accomplishes its objective via program evaluation. However, there are few studies showing the effects on both teachers and students, particularly on student achievement. The impact of PD on teachers, students, and schools is usually not well documented. As a result, evaluations of professional development have typically been an overlooked component in the education (Kutner, Tibbetts & Condelli, 1997).

Research suggests that teachers are not using skills learned in PD; and if teachers are, the skills are not implemented well (Johnson, 2006). Qualitative data collected from classroom observations revealed many teachers felt the pressure of teaching to the test and often felt they had the necessary skills to teach to the standards, but were forced to devote a majority of instructional time to prepare students for assessments (Westerlund, Upson, & Barufaldi, 2002). Additionally, Johnson (2006) found several barriers that prevent teachers from implementing reform. These barriers include technical, political, and cultural barriers, as well as lack of support from administrative staff. Research conducted by Fullan (2001), found teachers are central to reform efforts and should involve collaborative efforts from all administrators’, teachers’, and parents’ knowledge and practices (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Current PD programs do not address the existing beliefs, attitudes, and anxiety towards mathematics and science which have an effect on student learning (Johnson, 2006). Teachers must be well prepared to teach the challenging standards that can lead students to conceptual understand of science and mathematics (Loucks-Horsley & Matsumoto, 1999).

Teachers may lack the skills or pedagogy necessary to integrate science and mathematics. In a study by Douville et al. (2003), teachers who were integrating science and mathematics were more resource driven than conceptually driven. Connections are not made within a discipline, let alone across the disciplines (NRC, 1996; NCTM, 2000). When integrating one discipline into another, the teacher often does not know how to understand or teach the other discipline conceptually. For example, the teacher may be able to use the mathematics, but does not understand the mathematics conceptually. Douville et al. (2003) point out, in an example of a science teacher integrating mathematics into science, those instructional strategies for transitioning between narrative text (fiction) and expository (nonfiction) science text were absent. Reading expository text is problematic for many students. In order for students to transition from narrative reading to readers of expository science text, teachers must provide reading strategies to ensure expository science reading success. The students need a framework on which to build an understanding of how to read expository text, but the teachers did not include reading strategies when integrating literacy in science.

Correlated Science and Mathematics (CSM) is used to teach concepts rather than just skills and processes. For example, a concept in science could be cell size whereas learning the parts of the microscope and how to use the microscope would be considered skills. For example in mathematics, identifying the slope of a line would be considered a concept while learning how to use a calculator to graph the slope would be considered a skill. Inquiry based learning is recommended in both the mathematics standards (NCTM, 2000) and science standards (NSES, 1995). Inquiry based learning is student centered meaning the student is actively involved in learning, discovering, and understanding a concept. Many concepts in science and mathematics are not intuitive. According to Flores (2006), students will often state an explanation for a concept as fact merely because a higher authority such as the teacher told them so and, therefore, must be true. For example, when dividing fractions the rule is to invert the second fraction and multiply. Most people do not understand why this works; they just did as they were told. Using the inquiry based model, students discover the concept through an investigation and discussions of their findings with group members. Seaton & Carr (2005) examined the engagement of students in a classroom while attending an eight week ancillary co-curricular science and mathematics program. Students attended the Science, Engineering, and Mathematics Aerospace Academy. The researcher found the classrooms did not have effective instructional strategies such as inquiry, hands-on, or use technology. They noted that improving instructional strategies and moving toward "innovative and engaging instruction" is less likely to occur unless the teacher is confident and adequately prepared to implement reform practices in the classroom.

Professional Development – Teacher Confidence

Teachers need to have confidence in knowing that they have the capability to implement new technology and the knowledge of the secondary discipline in the classroom. To encourage teachers to move toward integrating science and mathematics in the classroom, professional development programs should include not only content knowledge of both disciplines, but also include the pedagogy by which teachers can implement these new teaching strategies (Czneriak, 2007).

Effective Integrated and Mathematics Science Professional Development Programs

Since 1997, Wright State University (WSU) has designed, implemented, and evaluated integrated science and mathematics PD programs for teachers in school districts in their region (Basista, 2002). Programs consisted of summer institutes, academic year support sessions, and workshops. Programs were thoroughly integrated and team-taught by both science and mathematics education faculty. After participation in these programs, teachers had a better understanding of science and mathematics content, their integration, and the methods to effectively teach these subjects in their classrooms (Basista, 2002).

Ohio State University created the preservice MSAT M.Ed. program that provides a comprehensive master's program integrating mathematics, science, and technology education. Both qualitative and quantitative data were collected to explore preservice teachers' attitudes and perceptions related to the integration of mathematics, science, and technology education. The quantitative analysis of the study revealed preservice teacher attitudes and perception related to the integration of mathematics, science, and technology still clearly positive, but less so than before the program. Berlin & White (2002) indicated this downward change in preservice teachers' attitudes towards the integration of mathematics and science may be related to a more realistic, practical, and cautious approach to integration. Prior to the program, preservice teachers did not mention any barriers or challenges, but recognized the difficulty and complex task to find or develop appropriate connections between mathematics and science. These findings were consistent with results from a study by Lehman & MacDonald (1988), who found that preservice teachers were less knowledgeable, but more positive about integrating than experienced, practicing teachers.

Barriers to Integrating Science and Mathematics

Through teacher interviews, Huntley (1998) identified several barriers to integrating science and mathematics. Teachers do not have the conceptual understanding that is required to integrate mathematics and science (Douville et al. 2003; Frykholm & Glasson, 2005). Several factors facilitate the integration of science and mathematics (Huntley, 1998). These include administrator support in class and student scheduling, proximity of mathematics and science classrooms to each other, joint planning time, and financial support for materials and professional development. Barriers to effective integration include a lack of time for team planning, combined disciplinary content, coordination of student assessment, and availability of materials (Huntley, 1998). The support of the district and school administration can impact the success of new and experienced teachers in implementing reform in the classroom as much as professional development (Johnson, 2006). Principals must be actively supportive in teacher collaboration, and the resources of time, materials and space (Johnson, 2006). Colleague support is also identified by Huntley (1998) as a factor that facilitates integration of science and mathematics.

Teacher attitude towards the integration of science and mathematics is also a concern. If a teacher perceives the integration of science into mathematics or mathematics into science as increasing their work load, then the teacher is not likely to implement integration in the classroom (Judson & Sawada, 2000). The confidence to teach mathematics and science are related so the teacher’s attitude toward either mathematics or science influences their attitude toward the other discipline (Utley, Bryant & Moseley, 2005; Bursal & Panokas, 2006). The integration of science and mathematics requires collaboration between not only the mathematics and science teachers, but as well as the administration of the school and the district (NSES, 1995, p. 218).

The Effects of Mathematics and Science Integration on Students Learning

The ultimate goal of most teacher PD and educational reform is a positive effect on students' understanding of science and mathematics. Research suggests that integrated lessons can improve engagement rates and therefore potentially improve student learning (Seaton & Carr, 2005; Seki & Menon, 2007). Also, according to Douville et al. (2003), students develop higher-order thinking skills and problem-solving skills when they make conceptual connections. Judson & Sawada (2000) conducted a study to determine the effect science and mathematics integration had on an 8th grade science class through the use of technology. The control was a grade 8 mathematics class that was beginning a unit on statistics. The treatment group was a grade 8 science class that integrated statistics into the science class. The control class used only a textbook for student learning, whereas, the experimental class used graphing calculators and probeware to construct, read, analyze and interpret data. Interestingly, the science teacher participated in PD called the Arizona Collaborative for Excellence in the preparation of Teachers physics and mathematics (ACEPT) summer seminar. The science teacher learned to use Calculator Based Laboratories (CBLs) during the summer PD and used this technology into his science classroom. Based on the on the results from the mathematics statistics unit test given to both groups, integration positively affected students' performance in their mathematics class. Only 35% of the students in the control group had grades A or B on the statistics unit test. Of the students from the experimental group, 75% had grades of an A or B. There was no difference in the science performance between the students in the integrated science class and the students in the nonintegrated science classes.

In Texas, student achievement is measured through the statewide assessment instrument, Texas Assessment of Knowledge and Skills, (TAKS). TAKS scores measure the district, school, and individual teachers' effectiveness to determine if the students have improved their understanding of science and mathematics concepts. Texas teachers are provided a great deal of PD in an effort to improve students' TAKS scores because the scores are reported by the state in the schools report card.

Curriculum Reform

The NSES promote science education reforms that include inquiry-based learning where the students are actively involved in their learning (1995). Most teachers do not implement the science education reforms suggested by NSES (Johnson, 2006), because many teachers have very little knowledge on reform practices such as inquiry and therefore, are reluctant to implement these practices in their classroom. Additionally, according to Berns & Swanson (2000), many teachers are inadequately prepared in both content knowledge and pedagogy to implement reform practices. The length and intensity of PD programs are related to improvement in teaching practices (Supovitz & Turner, 2000) and found that a large change in teaching practices occurred after 80 hours of professional development. Additionally, teachers' prior beliefs and experiences affect what they learn. Many teachers have deep seated beliefs of knowledge as facts, teaching as telling, and learning as memorizing (Cohen, 1998). These beliefs are barriers to reform and only when these beliefs are set aside can teaching for understanding occur

(Loucks-Horsley & Matsumoto, 1999). Learning new standards is difficult and it takes time. Teachers must face their deeply held beliefs about learning and knowledge and must reconsider their assumptions about students (Ball, 1998). “Most teachers, even if their beliefs are consistent with the new reforms, must develop new ways of teaching and assessing their work.” (Loucks-Horsley & Matsumoto, 1999, p. 261). “Fundamental change in practices and beliefs takes time, because there is much to unlearn and much that is complex to learn (Loucks-Horsley & Matsumoto, 1999, p. 261).

CHAPTER III

METHODOLOGY

Research Design

The *Mix It Up* teacher Professional Development (PD) program evaluation utilized a mixed method research design, which contained elements of both qualitative and quantitative data (Rocco, Bliss, Gallagher, & Perez-Prado, 2003). Quantitative data consists of numbers that can be counted or expressed numerically (Kachigan, 1986). In contrast, qualitative data uses nonstatistical means of analyzing data such as unstructured interviewing, observation, and document analysis (Schwandt, 1997). The major benefit of invoking both types of data collection is to strengthen inferences and outcomes of the research (Greene, J.C., Caracelli, V. J., & Graham, W. F., 1989). Additionally, “By combining multiple observers, theories, methods, and data sources, researchers can hope to overcome the intrinsic bias that comes from single-methods,” (Denzin, 1989, p. 307).

Participants

The Cohort IV *Mix It Up* PD was a continuation of *Mix It Up* trainings for cohorts I-III that occurred during summers 2006 and 2006 – 2007 school year. This study focuses only on cohort IV. The training for Cohort IV began summer 2008 and continued through the 2008 – 2009 school year. Teachers in Cohort IV included 10 mathematics and science teacher teams from grades 5-8 from five different campuses. All teachers were certified to teach in their teacher assignment 2008-2009 school years (see Table 1 for demographic information). Ten mathematics teachers and seven of the ten science teachers held temporary, alternative, or emergency certificates. Participants represented four different high need school districts as required by the funding agency Texas Higher Education Coordinating Board.

> ”A high-need school district is defined in federal regulation as a district that serves no fewer than 10,000 children from families with incomes below the poverty line or for which not less than 20 percent of the children served by the district are from families with incomes below the poverty line and for which there is a high percentage of teachers not teaching in the academic subjects or grade levels that the teachers were trained to teach or for which there is a high percentage of teachers with emergency, provisional, or temporary certification” (Teacher Quality RFP, 2008-2009).

Table 1. Demographic Analysis of Cohort IV
Teachers and Their Type of Teaching Certificate(s) and Teaching Assignment(s)

Year and Teacher Number		Type of Certificates	Teaching Assignments	Degree in Content Area	Student Teaching
Science Teachers					
08-01	Emergency	Grades 6-12, Science	Grade 7 Science	yes	no
08-03	Alternative	Grades 6-12 Life Science	Grade 8 Science	yes	no
08-04	Standard	Grades 6-12 Life-Earth Science	Grade 7 Science	no	yes
08-05	Alternative	Grades 7-12 Science	Grade 6 Science	yes	yes
08-08	Standard	Grades 4-8 Science Grades EC-4 Generalist	Grade 7 Science	no	yes
08-12	Alternative	Grades 4-8 Generalist	Grade 5 Science	no	No

Table 1 (Continued). Demographic Analysis of Cohort IV Teachers and Their Type of Teaching Certificate(s) and Teaching Assignment(s)

Year and Teacher Number		Type of Certificates	Teaching Assignments	Degree in Content Area	Student Teaching
08-13	Standard	Grades 8-12 Science	Grade 8 Science	no	yes
08-16	Alternative	Grades 6-12 Science	Grade 8 Science	no	no
08-18	Alternative	Grades 4-8 Science	Grade 8 Science	yes	no
08-19	Alternative	Grades 4-8 Generalist	Grades 7 Science	no	no
Mathematics Teachers					
08-02	Standard	Grades 4-8, Mathematics & Science	Grade 8 Mathematics	no	yes
08-06	Alternative	Grades 4-8 Mathematics	Grade 7 Mathematics	no	no
08-07	Standard	Grades 6-12 Mathematics	Grade 8 Mathematics	no	yes
08-09	Standard	Grades 4-8 Generalist	Grade 7 Mathematics	no	yes
08-10	Standard	Grades 1-8 Mathematics	Grade 7 Mathematics	no	yes
08-11	Standard	Grades 4-8 Generalist	Grade 5 Mathematics	no	yes
08-14	Standard	Grades 4-8 Generalist	Grade 6 Mathematics	no	yes
08-15	Temporary	Grades 4-8 Generalist	Grade 7 Mathematics	no	no
08-17	Alternative	Grades 4-8 Mathematics	Grade 6 Mathematics	no	No
08-20	Emergency	Grades 6-12 Mathematics	Grade 8 Mathematics	yes	no

The teacher demographics were analyzed by reviewing transcripts, teaching certificates, and teaching assignments. Transcripts were analyzed to determine the quantity of each teacher’s content background in physics, life science, chemistry, earth/space science, as well as mathematics. Only content courses with a grade of C or better were counted.

Course and Lesson Plan Development

The Correlated Science and Mathematics (*CSM*) lessons were designed using a modified version of the Japanese lesson study. The Japanese lesson study model is a PD process where Japanese teachers systematically engage in examining their practice with the goal of becoming more effective (Rearden, Taylor & Hopkins, 2005). These professionals collaborate to draw up a potential lesson plan, observe the lesson, discuss observations of the lesson, and then revise the lesson plan (Rearden et al. 2005). The project director of the *Mix It Up* PD, instructors of the courses, as well graduate students, met before, during, and after the PD for the purpose of tailoring content, resources, and collaborative efforts to better meet the needs of the participants. Participant feedback was analyzed using participant daily reflections of each of the lessons each day to measure the effectiveness of the project goals. Daily post-lesson meetings of the instructional team and other peer observers were used as formative assessment nd revision of the subsequent lesson. The second goal of the PD was to improve teacher pedagogy by modeling research based best practices. Therefore, lessons included practices that were student centered, such as using a version of the 5E lesson plan. Additional teaching strategies included the use of technology and science and math manipulatives to enhance learning.

Research Procedure

Cohort IV attended an intense two-week summer training, and four Saturday Academic Year (AY) follow-up sessions. Teachers received training in Correlated Geology and Mathematics and Correlated Space Science and Mathematics. Additional training opportunities were offered at either the Conference for the Advancement of Science Teaching (CAST) or the Conference for the Advancement of Mathematics

Teaching (CAMT) and served as one academic year (AY) session. Two AY sessions were held in the fall of 2008 and two were held during the spring of 2009. Stipends were paid based upon attendance.

One of the main goals of the *CSM* training was to model and teach participants knowledge and skills needed to link mathematics and science and develop an understanding of how to incorporate integrated science and mathematics into their teaching practices. An integrated science and mathematics lesson occurs where math is used as a tool to teach science concepts. For example, balancing chemical equations in chemistry is viewed as integration because science is using mathematics as a tool to help students understand conservation of matter as seen in the need to balance equations (Vasques-Mireles & West, 2007). Also, an integrated lesson can be solely taught by either a mathematics instructor or a science instructor, whereas, a *CSM* lesson must be taught by a science expert and mathematics expert. Each discipline is taught with seven fundamental goals as mentioned previously. The July training was designed to enhance teacher content knowledge in mathematics and science and model and teach participants how to indentify content appropriate for integration or correlation.

The teachers received three hours of training in integrated space science and mathematics in the morning (see Table 2).

Table 2. Professional Development Training Schedule for Correlated Space Science and Mathematics Course

Correlated Space Science and Mathematics 8:30 – 11:30	Space Science	Mathematics
Week 1 Monday	Pretests Marbles and Funnels Forces, Orbital Motion, Ellipses	Calculator Training Vectors, Conic Sections, Distance, Sums, Ratio
Tuesday	Shapes, Scaling Evaluation	Ratio, Sections, Ratio Reasoning
Wednesday	Phases of The Moon Modeling Earth, Moon, Sun Configurations, Moon Phases	Angles, Projections
Thursday	Orbital Periods	Proportions, Reference Frames
Friday	Seasons on the Earth Intensity of Light Distance from Sun	Angle, Area, projections, Inverse Proportion, Exponents
Week 2 Monday	Modeling of Earth, Sun – Tilt of Earth’s Axis	Angle, Area, projections, Inverse Proportion, Exponents
Tuesday	Solar system Properties Scale Drawing of Solar System The “Solar system Game” Orbital Periods and Distances Energy and Atmospheric Molecules	Units Ratios, exponents Algorithms, graphing, tables

Table 3. Professional Development Training Schedule for Correlated Geology and Mathematics Course

Correlated Geology and Mathematics 12:30 – 4:30	Geology Content	Mathematics Correlations
Week 1 Monday	Minerals a. Rocks vs minerals b. Physical & Chemical Properties of Minerals	Crystal Shape using models. Geometric shapes & angles Measurement – Precision Ratios Visualizing 3D graphs Exponential Relationship-J curve for Hardness test.
Tuesday & Wednesday	Rocks a. Igneous – Salol lab b. Sedimentary c. Metamorphic	Graphing skills/rules-Bar graphs with line graph super-imposed Mean, median, mode, and range
Thursday	d. Coal Mining Activity Destruction Forces e. Weathering f. Erosion-Melting	TI 84 Spreadsheet Skills Surface area scatter plot Graphing
Friday Week Two & Monday	Earth History a. Scale Model of Geologic Timeline b. Fossil Prints Activity c. Metric-Asaurus Lab	Measurement Estimation for Reasonableness Ratio & Proportion Exponential Decay Ratio
Tuesday and Wednesday	Texas Geology (Karst Topography) Prep for Llano Trip – Road Log	
Thursday	Llano field trip	
Friday	Team Lessons Post Tests Program Evaluations	

The Correlated Space Science and Mathematics course was taught by an instructor who is a physics expert with a Master's of Science in Physics and a mathematics minor, but lacks science pedagogy expertise and is a mathematics education instructor who has a Master's in Mathematics and PhD in Mathematics Education. The course included space science concepts such as ellipses, orbital motion, phases of the moon, light intensity, position, motion, speed, accuracy and force. The mathematics concepts such as measurement, coordinate graphing, proportions, angles, ratios, vectors, exponents, algorithms. The *Correlated Geology and Mathematics* was a daily four hour class and team taught by a mathematics and geology instructor. The *CGM* class included concepts such as rocks, minerals, physical and chemical properties of minerals, types of rocks, weathering and erosion, and fossils. Mathematics concepts that were taught included crystal shape, geometric shapes and angles, J curve using Moh's hardness scale, and scatter plot, measurement, surface area, and graphing ratios and proportions. The *CGM* course included a geology field trip to Llano, Texas that allowed teachers to collected igneous, metamorphic, sedimentary rocks, and minerals to build their own personal geology teaching collection.

Data Collection and Instruments

Content knowledge was measured via pre and post testing which was designed to measure the content level of knowledge of teachers prior to the PD and at the conclusion of the PD training. At the conclusion of the summer training, teachers were given a post test identical to the pretest. The geology pretest had 28 multiple choice questions. The mathematics test had 20 multiple choice questions. Questions on the geology and mathematics tests were selected from released PRAXIS (http://www.ets.org/praxis), and

TExES (http://www.texes.ets.org/texes/) teacher certification exams. The space science test was instructor-generated and contained 21 open ended questions over topics previously mentioned.

Table 4. Quantitative and Qualitative Instruments Used to Answer PD Research Questions

Method	Objective
Quantitative Instruments	
Teacher pre and post tests	Teacher content knowledge
Student pre and post tests	Student content knowledge
Students TAKS Scores	Student content knowledge
Method	**Objective**
Qualitative Instruments	
Teacher Summer Daily Reflections	Pedagogy CSM Understanding
Teacher AY Reflections	Pedagogy CSM Understanding
PD Program Evaluation	PD Satisfaction
Teacher Observation	Teacher Pedagogy
Structured Interview/Observation	Ability to Teach Integrated Lessons
Principal Interview	Teacher Pedagogy and Effectiveness
Student Reflections	Student perceptions

Qualitative instruments were used to measure pedagogy. The second goal of this research was to improve teacher pedagogy by discussing best teaching practices during the training and debriefing after lessons to identify which best practices were used by the instructor during the lesson. Best teaching practices are recommended by the National Science Education Standards (NSES, 1996). This goal was measured qualitatively by analyzing teacher summer reflections, observing and interviewing teachers at least once during the academic year, and by reviewing reflections after the academic year sessions. During the summer training, teachers were required to journal their impressions of the lesson after the morning session and once again after the afternoon session. Concluding each lesson, teachers were required to review the lesson and write what they liked or disliked about the lesson, what they did or didn't know before the lesson, and were reviewed daily by the project director and instructional team as formative assessment. The necessary adjustments in the training were identified in areas where the instructors needed to clarify or re-teach.

Qualitative instruments were used to measure participant's ability to design and teach an integrated lesson. Qualitative instruments included teacher structured interviews, observations, and principal interviews and were used to measure the third goal of this study. Teacher interviews and observations were conducted at least once during the academic year of 2008 and 2009. Teacher teams were asked to teach either a correlated or integrated science or math lesson. A Correlated Science and Math Observation form was used to observe and interview teachers and principals and to measure improvement in teacher pedagogy, to determine if teachers were integrating science and mathematics in their classroom. Teacher interviews were conducted after observing the lesson. Questions were asked to determine how often teachers taught integrated science and mathematics lessons in the classrooms and to identify any barriers preventing teachers from teaching integrated science and math lessons.

Qualitative data such as student reflections were a measure used to determine how much impact the CSM training had on student learning. At the conclusion of the observed lesson, students were asked to reflect on the lesson. The student reflections consisted of four open ended questions which were designed to measure students' enjoyment of an integrated lesson compared to traditional lessons and if they learned anything new from having been exposed to an integrated lesson. Principal interviews were conducted at each school using the Correlated Science and Mathematics Observation Form developed by project directors Dr. Sandra West and Dr. Sandra Browning and was used to perceive impact on the teacher's pedagogy and student performance and the extent to which teachers' implemented integrated lessons. After conducting the observations and interviews, project directors met to write a summary of their notes.

The student pre and post tests were used to answer the fourth research question which was to measure the impact the PD had on grades 5-8 student achievement of the teachers'. Student achievement was quantitatively measured using two instruments: pre and post tests and the Texas Assessment of Knowledge and Skills (TAKS). Student reflections were also used to gain insight into student learning. At the beginning of the school year, students of the teachers were given a pretest on concepts taught during the PD in either science or mathematics. Participating science teachers administered the science test which consisted of 30 multiple choice geology and space science questions (See Table 5). Likewise, mathematics teachers administered the mathematics test which consisted of 25 multiple choice questions (See Table 6). Identical tests were administered at the end of the school year (Spring 2009). The space science and geology test items were taken from released Texas Assessment of Knowledge & Skills (TAKS), Investigating the Earth Teachers Guide Part 1 (Earth Science Curriculum Project, 1967), State of New York Science Test, and State Teacher Certification Exam Praxis. The same test was administered as a post test and consisted of 30 multiple choices questions on previously listed concepts. The mathematics test contained questions from TAKS, Massachusetts Comprehensive Assessment Skills (MCAS), and Virginia Standards Learning Assessment (VSLA) on concepts delineated earlier. Tested mathematics concepts included measurement, quantitative reasoning, algebraic reasoning, number sense and operations, geometry, probability, spatial reasoning, and data analysis.

Table 5. Cohort IV. Student Space Science and Geology Pre and Post Test Questions and Sources

Test Item	Category	Source
2	Minerals	Grade 8 TAKS Science 2006
3	Measurement TAKS Obj. 1	Grade 8 TAKS Science 2006 (Instructor created from fill in the blank
4	Weathering TAKS Obj. 5	TAKS Science
9	Fossil Formation	Grade 5 TAKS Science 2006
10	Geologic Time TAKS Obj. 5	Grade 5 TAKS Science 2006
11	Measurement TAKS Obj. 1	Grade 5 TAKS Science 2006
12	Weathering TAKS Obj. 5	Grade 5 TAKS Science 2006
19	Geologic Time TAKS Obj. 5	TAKS Science (Instructor created from fill in the blank)

Table 5. (Continued). Cohort IV. Student Space Science and Geology Pre and Post Test Questions and Sources

Test Item	Category	Source
20	Measurement TAKS Obj. 1	TAKS Science (Instructor created from fill in the blank
23	Phases of the Moon TAKS obj.	Grade 8 TAKS Science 2006
25	Phases of the Moon TAKS Obj. 5	Grade 8 TAKS Science 2006 (Instructor created from fill in the blank)
28	Seasons TAKS Obj. 5	TAKS Science
30	Lunar Eclipse TAKS Obj. 5	Grade 8 TAKS Science 2006
5	Minerals	State of New York Science Test Grade 8 May 2006
6	Rocks	State of New York Science Test Grade 8 May 2006
7	Weathering TAKS Obj. 5	State of New York Science Test Grade 8 May 2006
8	Measurement TAKS Obj. 1	State of New York Science Test Grade 8 May 2006
24	Phases of the Moon TAKS obj. 5	State of New York Science Test Grade 8 May 2006
26	Earth’s Revolution TAKS Obj. 5	State of New York Science Test Grade 8 May 2006
27	Earth’s Revolution TAKS Obj. 5	State of New York Science Test Grade 8 May 2006
1	Geologic Process TAKS Obj.	Investigating the Earth Teachers Guide Part 1

Table 5. (Continued) Cohort IV. Student Space Science and Geology Pre and Post Test Questions and Sources

Test Item	Category	Source
15	Density TAKS Obj. 1	Investigating the Earth Teachers Guide Part
13	Geologic Process TAKS Obj. 5	Praxis Knowledge Test Science Content
16	Geologic Time TAKS Obj. 5	Investigating the Earth Teachers Guide Part
17	Geologic Time TAKS Obj. 5	Investigating the Earth Teachers Guide Part
18	Geologic Time TAKS Obj. 5	Investigating the Earth Teachers Guide Part
14	Density TAKS Obj. 1	Quiz 5, GS 3310, SS 2008
21	Position	Instructor Created
22	Phases of the Moon TAKS Obj. 5	Praxis Chapter 13
29	Seasons TAKS Obj. 5	Praxis Chapter 13

Table 6. Cohort IV. Student Mathematics Pre and Post Test Questions and Sources

Test Item	Category	Source
1	Measurement	Grade 8 TAKS Math 2006
2	Numbers, Operations, and Quantitative Reasoning	Grade 8 TAKS Math 2006
3	Patterns, Relationships, and Algebraic Reasoning	Grade 8 TAKS Math 2006
4	Measurement	Grade 8 TAKS Math 2006
5	Numbers, Operation, and Quantitative Reasoning	Grade 8 TAKS Math 2006
6	Mathematical Tools and processes	Grade 8 TAKS Math 2006

Table 6. (Continued). Cohort IV. Student Mathematic Pre and Post Test Questions and Sources

Test Item	Category	Source
7	Patterns, Relationships, and Algebraic Reasoning	Grade 8 TAKS Math 2006
8	Geometry and Spatial Reasoning	Grade 8 TAKS Math 2006
9	Measurement	MCAS Grade 8 Spring 2007 (Instructor created from open ended)
10	Numbers Sense and Operations	MCAS Grade 8 Spring 2007
11	Numbers Sense and Operations	MCAS Grade 8 Spring 2007
12	Data Analysis, Statistics, and Probability	MCAS Grade 8 Spring 2007
13	Patterns, Relationships, and Algebraic Reasoning	MCAS Grade 8 Spring 2007
14		MCAS Grade 8 Spring 2007
15	Number Sense and Operations	VSLA Grade 8 Math Spring 2003
16	Computation Estimation	VSLA Grade 8 Math Spring 2003
17	Measurement and Geometry	VSLA Grade 8 Math Spring 2003
18	Probability and Statistics	VSLA Grade 8 Math Spring 2003
19	Probability and Statistics	VSLA Grade 8 Math Spring 2003
20	Patterns Functions and Algebra	VSLA Grade 8 Math Spring 2003

Statistical Analysis

Participant Data

Teacher pre and post tests were analyzed with randomization tests that are appropriate when the data to be analyzed does not meet the assumptions required for customary statistical tests (Sokal & Rohlf, 1995, p. 803). The randomization was performed on the mathematics and science teachers together and separately. Although Cohort IV consisted of 20 teachers, two mathematic teachers did not take the post test, and therefore, were not included in the analysis. In this case, a randomization test was used because of the possibility of violating the assumption of normality with a small sample size. A small sample size is defined by having samples of less than 20. The cohort consisted of 10 mathematics and 10 science teachers. A randomization test compares the test statistic of the sample to a randomly reordered set of data from the sample; a more commonly used statistical analysis test would give the same results within the same sample (Manly, 1991). The test statistic (ts) value was calculated as the sum of the differences between the pre and post test from the randomly reordered set of data. A computer software program called "R software" (R, 2006) was used for the quantitative data analysis.

Student Data

The student pre and post tests were analyzed using descriptive statistics such as mean, median, mode, range, standard deviation, and standard error. Descriptive statistics are used to analyze the properties of an observed frequency distribution concisely and accurately (Sokal & Rohlf, 1995). The mean and standard deviation will be calculated on the mathematics and science student pre and post tests. The standard deviation describes the spread of a distribution by analyzing how far the observations are from the mean. The results were plotted on a bar graph which described trends and patterns within the data set.

Validity Concerns and Issues

The tools used to achieve validity must measure the measurements it is intended to measure. “Validity is the extent to which any measuring instrument measures what it is intended to measure” (Carmines & Zeller, p. 17). To insure validity, it is very important to mix quantitative and qualitative methods to increase the validity of findings in research (SenGupta, 1993). This research study utilizes both quantitative and qualitative data to address the issue of validity. Internal and external validity will be addressed to assess the instruments used in this study.

Internal Validity - Teachers

Internal validity is defined as the "approximate validity with which we infer that a relationship between two variables is causal" (Cook & Campbell, 1979. p.37). The test questions used to measure teacher content knowledge in mathematics and geology came from released state validated tests. Additionally, the test questions were carefully chosen to measure the content teachers learned during the PD. Potential threats to the internal validity of the teacher pre and post tests results should be considered. The project staff emphasized the role of the pre and post tests in program evaluation and teacher evaluation. Threats to internal validity include the possibility of teachers influencing scores on other teachers’ post test.

Internal Validity - Students

Internal validity may have affected the student pre and post tests. The questions on the science and mathematics pre and post test were taken from state validated test items. However, the validity of the questions was addressed, but, the majority of the science test consisted of 8th grade released TAKS questions. Released TAKS questions are used for student benchmarking and students may have been exposed to these types of questions prior to the administration of the student pretest. Also, because the majority of the questions consisted of 8th grade content, students in the 7th, 6th, and 5th grades of this cohort of teachers were not tested on content they learned during the academic year. Other threats to interval validity are the possibility that over the course of the academic year; students may have discussed questions on the tests which could influence scores on the post test. However, the researcher expects this threat is minimal and is expected that student learning over the course of a year would have a greater affect on the post test. To effectively measure the goals of the PD, teachers were asked not to discuss the tests with their students. However, teachers may have discussed the content on the exams with the students. Also, teachers may have encountered curriculum restraints influencing student knowledge and therefore influencing scores on the post tests.

External validity

The only threat to external validity that could be foreseen was how representative the students were of general student population. The total number of students was dependent on their class assignment for the 2008 – 2009 school year. However, because students were randomly assigned to participating teachers, the student sample therefore serves as a representative sample of that grade level's students at the participating school. Because students are randomly assigned to classrooms, results can be generalized to other urban middle schools with similar populations.

Reliability Issues and Concerns

Reliability is the consistency of the measurement, or the degree to which an instrument measures the same way each time it is used under the same condition with the same subjects (Golafshani, 2003). "The more consistent the results given by repeated measurements, the higher the reliability of the measuring procedure; conversely the less consistent the results, the lower the reliability." (Carmines & Zeller, 1979, p. 12). The teacher pre and post test items were taken from released Praxis , TExES, and New York Regency State Certification exams. Validated student pre and post test science questions were taken from released TAKS, State of New York Science, Praxis, Investigating the Earth Teachers Guide Part I, and mathematics questions were taken from TAKS, MCAS, and VSLA state exams. Reliability was addressed in this study by using pre and post tests from reliable test banks.

CHAPTER IV

RESULTS

Transcript Analysis

The transcripts of 20 teachers were analyzed to determine each participant's credit hours in science and mathematics courses, as well as either a science or mathamatics methods course (see Table 7). All of the participants were certified in their content, but the majority had baccalaureate degrees in a major other than their science or mathematics teaching assignment. The transcripts revealed half of the participants were high need (because the teacher received certification either through alternative, temporary, or emergency certifications. One teacher had just been hired with Emergency certification. One participant had a Masters Degree in Education and one participant had a Bachelor of Science Degree in Science. Therefore, those two teachers were removed from the analysis as outliers because the content portion of the PD program was specifically geared towards high need middle school teachers based on their certification and their level of content background. Additionally, to qualify for this funded project, one team member had to be high need as defined by the Texas Higher Education Coordinating Board grants. The mean number of college science hours for the remaining 16 teachers is 2.9 with a range of 0-33. The mean number of college mathematics hours is 5.8 ranging 0-15 (Table 8). The science or mathematics methods courses did not count toward as per the granting agency guidelines.

Table 7. Cohort IV Transcript Analysis: Number of College Course Semester Hours

Teacher code: Year-Teacher number	Mathematics	Physics	Chemistry	Earth	Space	Biology	Science Methods	Math Methods
Science Teachers								
08-01	3	10	12	3	-	13	-	-
08-03	-	-	16	-	-	43	-	-
08-04	4	-	-	-	-	3	-	-
08-05	-	-	4	-	-	24	-	-
08-08	-	8	-	3	-	3	-	-
08-12	-	-	-	-	-	3	-	-
08-13	4	8	11	11	-	8	3	-
08-16	-	-	8	11	-	23	-	3
08-18	-	8	8	-	-	39	-	-
08-19	-	9	-	-	-	-	-	-
Math Teachers								
08-02	19	4	4	8	-	13	3	3
08-06	18	29	3	3	-	-	-	-
08-07	30	8	4		-	-	-	-
08-09	9	-	4	-	-	4	-	-
08-10	15	-	-	6	-	-	-	-
08-11	3	-	-	7	-	-	-	-
08-14	6	-	4	-	8	3	3	-
08-15	-	-	-	-	-	6	-	-
08-17	-	-	-	-	-	-	-	-
08-20	30	-	-	-	-	4	-	-

Table 8. Cohort IV Summary of Transcript Analysis: Number of College Course Semester Hours Excluding Outliers

	Mathematics	Science	Science Methods	Mathematics Methods
Mean	5.8	4.3	3	3
Median	4	0	3	3
Range	0-15	0-33	0-3	0-3

Science and Mathematics Teachers' Content Knowledge

The first research question of the PD was to measure teacher knowledge of mathematics and science. Pre and post tests were administered for the mathematics, space science, and geology prior to the professional development and after the professional development program. To assess knowledge gained from the professional development a randomization test was conducted on the mathematics and science together and mathematics and science teachers' data separately.

Mathematics Test

Results of the mathematics assessment for the individual teachers are shown Table 9. Two mathematics teachers did not take the any of the three post tests because of approaching tropical storm in South Texas. These two were eliminated from the analysis. Therefore, 18 teachers were included in the analysis of the mathematics tests. Individual teacher scores are listed in Table 5.

Table 9. Teacher Mathematics Pre and Post Test Scores and Percent Change

Teacher	PreTest Score	Post Test Score	Percent Change
8th Grade Mathematics			
08-02	70	85	15
08-07	65	90	25
08-20	90	95	5
8th Grade Science			
08-03	55	45	-5
08-13	90	95	5
08-16	60	65	5
08-18	60	65	5
7th Grade Mathematics			
08-06	90	85	-5
08-09	90	n/a	-
08-10	65	80	15
08-15	70	n/a	-
08-17	80	85	5
7th Grade Science			

Table 9 (Continued). Teacher Mathematics Pre and Post Test Scores Percent Change

Teacher	PreTest Score	Post Test Score	Percent Change
08-01	70	85	15
08-04	55	60	5
08-08	45	50	5
08-19	80	80	0
6th Grade Mathematics			
08-05	70	70	0
6th Grade Science			
08-14	65	75	10
5th Grade Mathematics			
08-11	60	45	-15
5th Grade Science			
08-12	70	80	10

The randomization test was conducted separately on the mathematics and science teachers’ data to determine if there was a difference in the amount of mathematics learned between the science and mathematics teachers. Results from the randomization test are shown in Table 10. According to the *p*-value from the randomization test, there was no significant gain in mathematics content knowledge as a group and for mathematics and science teachers separately.

Table 10. Teacher Mathematics Results from the Randomization Test

Test	ts	n	*p*
Mathematics Test			
All Teachers	-95	18	.1631
Mathematics Teachers	-65	8	.1506
Science Teachers	-30	10	.356

*p<.05.**p<.01.***p<.001

Space Science Test

Results of the individual teachers are shown Table 11. Where data are available, all but two teachers demonstrated an improvement between pre- and post-test scores (Table 11).

Table 11. Teacher Space Science Pre and Post Test Scores with Percent Change

Teacher	Pre Test Score	Post Test Score	Percent Change
8^{th} Grade Mathematics			
08-02	29	81	52
08-07	15	56	41
08-20	40	47	7
8^{th} Grade Science			
08-03	45	36	-9
08-13	61	88	27
08-16	45	45	0
08-18	45	79	34
7^{th} Grade Mathematics			
08-06	20	52	32

Table 11 (Continued). Teacher Space Science Pre and Post Test Scores with Percent Change

Teacher	Pre Test Score	Post Test Score	Percent Change
08-09	31	n/a	-
08-10	36	54	18
08-15	40	n/a	-
08-17	15	54	39
7th Grade Science			
08-01	43	54	11
08-04	27	36	9
08-08	47	61	14
08-19	61	79	18
6th Grade Mathematics			
08-14	22	59	37
6th Grade Science			
08-05	36	45	9
5th Grade Mathematics			
08-11	27	31	4
5th Grade Science			
08-12	40	54	14

To determine the content gained in space science, a randomization test was performed on the mathematics and science teachers' scores together, and then performed on the mathematics and science teachers separately (see Table 12). The *p*-value from each randomization test demonstrates there was significant gain in space science content knowledge as a group and math and science teachers separately.

Table 12. Teacher Space Science Results from the Randomization Test

Test	ts	n	*p*
Space Science Test			
All Teachers	-329	18	.0004
Mathematics Teachers	-199	8	.0012
Science Teachers	-130	10	.0397

*p<.05.**p<.01.***p<.001

Geology Test

Results of individual teacher scores, as well as percent growth are shown in Table 13. Scores of mathematics and science teachers were separated. All teachers improved on the post test except one teacher, who scored the same on the post test.

Table 13. Teacher Geology Pre and Post Test Scores Percent Change

Participant	PreTest Score	Post Test Score	Percent Change
8^{th} Grade Mathematics			
08-02	67	96	29
08-07	67	67	0
08-20	42	53	11
8^{th} Grade Science			
08-03	46	67	21
08-13	78	82	4
08-16	64	85	21
08-18	71	85	14
7^{th} Grade Mathematics			
08-06	57	67	10

Table 13 (Continued). Teacher Geology Pre and Post Test Scores Percent Change

Participant	PreTest Score	Post Test Score	Percent Change
08-09	57	n/a	-
08-10	57	67	10
08-15	46	n/a	-
08-17	42	85	43
7th Grade Science			
08-01	53	71	18
08-04	25	53	28
08-08	42	60	18
08-19	71	92	21
6th Grade Mathematics			
08-14	21	67	46
6th Grade Science			
08-05	46	64	18
5th Grade Mathematics			
08-11	35	71	36
5th Grade Science			
08-12	42	75	33

A randomization test was performed on the data of the mathematics and science teachers together, and then performed on the mathematics and science teachers separately. Results from the randomization show a significant gain in content knowledge at all three levels (Table 14).

Table 14. Teacher Geology Results from the Randomization Test

Test	ts	n	*p*
Geology Test			
All Teachers	-384	18	.0004
Mathematics Teachers	-186	8	.0049
Science Teachers	-198	10	.005

*p<.05.**p<.01.***p<.001

Qualitative Data

In addition to the pre and post tests, qualitative data such as daily teacher reflections, teacher lesson plans, final summer program evaluation, and academic year evaluation were obtained. The teachers were confronted with their lack of knowledge in science and mathematics. One science teacher's reflection revealed after taking the science pretest, "I did not know that I needed so much help in science." At the conclusion of the PD, teachers felt more confident in teachings concepts such as the rock cycle. One science teacher shared, "I didn't know the rock cycle as well as now. I can explain the rock cycle better to my students now." A mathematics teacher expressed new knowledge of phases of the moon. "I enjoyed learning about the phases of the moon. I had no real knowledge of this subject matter until this lesson." Lastly, reflections indicated that they developed a better understanding of space science, geology, and mathematics; the best-practices modeled by the instructors helped participants to deepen their content knowledge in mathematics, space science, geology and their pedagogy.

Improvement in Instructional Skills

The second research question of the *Mix It Up* PD program was to measure teacher instructional skills by modeling research based best-teaching practices. The qualitative instruments used in this research included daily reflections, structured principal and teacher interviews, and observations. Daily reflections and summer program evaluations revealed that teachers realized the importance and applicability using research based best-teaching practices. Teachers realized importance of specifically using models in their own learning and thus, the importance in student learning. During a space science lesson on phases of the moon which utilized models, one science teacher discovered that she had been teaching phases of the moon incorrectly.

Teachers enjoyed the hands-on activities that were used during lessons and felt their students would enjoy and understand the science and mathematics conceptually if hands on activities such as models, and math manipulatives were included. Specifically, teachers found the benefit of using models to understand difficult concepts, especially for middle school students, such as the reasons for the seasons and the phases of the moon. Teacher comments included, “The manipulatives made it easy to visualize and understand conceptually.” ”I learned if the Earth does not rotate, life as we know would not be possible.” Furthermore, “Models helped me to visualize the concept taught – convinced me that it is very effective, as well as to teach the students through modeling concepts.” Other teachers realized the effectiveness of using inquiry to teach concepts to students. During a space science lesson, teachers were presented with the question, “What if the earth did not rotate on its axis?” Through in-depth discussions with their fellow teachers, they discovered how a “Good inquiry lesson should stimulate thoughtful student discussions”.

Integrated Lesson Implementation

The third research question of this project was to measure the abilities of teachers to design and teach integrated mathematics and science lessons in their classrooms. However, during the summer it was possible for teachers to team teach a *CSM* lesson because the teams were together with planning and implementation of a *CSM* lesson unlike during the school year. This team teaching requirement was to initiate and facilitate conversations between the team members in the hope that they would continue the collaboration when they returned to their school. In contrast, during the school year when teachers are typically not able to team teach, a goal of the project is to teach integrated lessons. All teachers were required to teach a correlated lesson with their partner at the conclusion of the summer PD. However, due to time constraints, only four lessons were observed and peer reviewed. Participants who were unable to teach their *CSM* lessons during the summer taught their lesson at an AY session.

Three lessons were correlated and one was integrated. Team correlated lessons used the 5E Inquiry format and utilized hands-on activities. Team reflections and peer evaluations revealed several themes. The peer reflections revealed in one particular science and math lesson, the content specific language were not appropriately used. For example, the words weight and mass were used interchangeably. The teachers recognized this language issue as potentially leading to student misconceptions. One grade 7 team member, who had a 20 year old biology degree but was new to the classroom, revealed he did not feel confident teaching the lesson because he did not have the content and pedagogy to be effective.

Qualitative instruments such as teacher interviews and observations, as well as principal interviews, were conducted to see determine how effectively participants were implementing accurate content and appropriate content pedagogy in their classrooms. All teachers were interviewed and observed except for one teacher who was pulled from the classroom for administrative duty. Of the nineteen participants only one lesson observed was a correlated lesson. Out of the remaining 18, 14 of the teachers presented an integrated lesson.

Statistical Analysis for Student Achievement

The last research question of the project was to measure if the PD training had any effect on student learning. Mathematics teachers administered a mathematics pretest to their students and students of science teachers received a science pretest. At the end of the year the same students took an identical mathematics or science post test. The mathematics test consisted of 20 multiple choice questions carefully chosen by the instructors to ensure questions aligned with concept objectives of the program. The questions were carefully chosen from released 5th and 8th grade TAKS Science test, Virginia Standards Learning Assessment, and Massachusetts Comprehensive Assessment Skills. The science pretest included 30 multiple choice questions on the geology and space science concepts taught in the PD. The students recorded their answers on scantrons which were electronically graded by the researcher.

Grade 8 Mathematics and Science

To evaluate the effectiveness of the PD impact on student achievement, one control class was used to compare the treatment to the non-experimental group. The control (non-experimental) consisted of students of an 8th grade science teacher from a participating school, who did not participate in the PD. Control classes for the 8th grade mathematics and remaining grades in science and mathematics portion of the study were not available for this cohort.

Results for the 8th grade mathematics and science students are shown in Table 15 and Figures 2 and 3. Students of all three 8th grade mathematics teachers took the mathematics pretest. Likewise, students of all four science teachers took the science pretest. Data from one mathematics (02) teacher and one science (18) was not included in the analysis because the student pre and post tests could not be matched. The average score on the mathematics pre test for 8th grade mathematics students ranged from 31.7% (s=18.9) to 50.2% (s=16.8) and 42.8% (s=17.38) to 58.1% (s=12.72) on the post test. The average increase for the 8th grade mathematics students was 20%. Students of teacher 20 had a lower average score on the pre and post than teacher 07. However, teacher 20 had a higher percent growth than the other 8th grade mathematics teacher (07).

Table 15. Students' Pre/Post Results for 8th Grade Mathematics and Science

Teacher	Mean Pretest score	Standard Deviation	Mean Post Tests Score	Standard Deviation	Percent Increase
Mathematics					
08-07	50.2	16.3	58.1	12.7	14
08-20	31.7	24.4	42.8	17.4	26

Table 15 (Continued). Students' Pre/Post Results for 8th Grade Mathematics and Science.

Teacher	Mean Pretest score	Standard Deviation	Mean Post Tests Score	Standard Deviation	Percent Increase
Science					
08-03	55.5	15.6	63.5	15.9	12.6
08-13	49.5	14.2	55.2	14.2	10.3
08-16	49.0	12.6	62.1	14.4	21
Control	49.1	14.7	57.3	14.8	14.3

The results from the two 8th grade mathematics teachers show a positive trend of improvement in student post scores (Figure 2). Students of teacher 08-07 had a higher average on the pre and post tests. However, the standard deviation within each sample is similar and overlaps the differences between the teachers' pre and post test scores. The overlap may suggest that there is no significant improvement on the post tests.

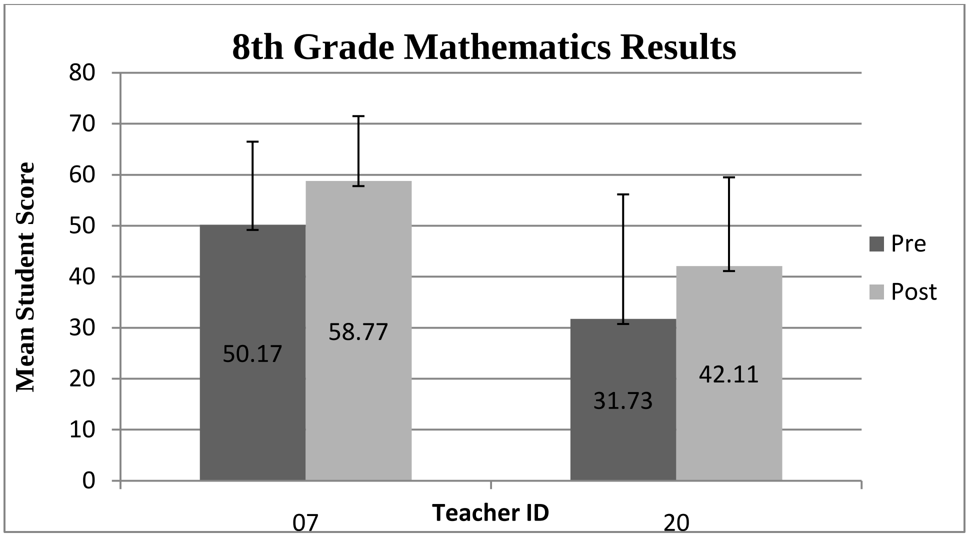

Figure 2. Mean Pre and Post Test Scores with Standard Deviation for 8th Grade Mathematics Students.

Grade 8 Science Students

Students of the 8th grade science teachers show a similar trend. Student pretest scores ranged from 49.4% (s=12.5) to 55.5% (s=15.6) and 55.2% (s=14.1%) to 63.5% (s=15.9) on the post test (Table 15.). The mean percent increase for the student post test was 19.4%. Students of teacher 08-03 had the highest pre and post test score, whereas, students of teacher 08-16 had the highest percent growth. The 8th grade science control students showed similar trends with a mean percent increase of 14.3%. Comparing students of the 8th grade science control with students of the 8th grade science teachers, the control showed a similar trend. Results from the 8th grade science student analysis are shown graphically in Figure 3. The standard deviation between the student pre and post test scores for 8th grade science teachers and the control overlap, which may suggest there is no significant improvement. It appears that students of teacher 08-16 may have had significant improvement on the post test. Comparing the standard deviation between the pre and post test, the standard deviation does not overlap suggesting significant improvement.

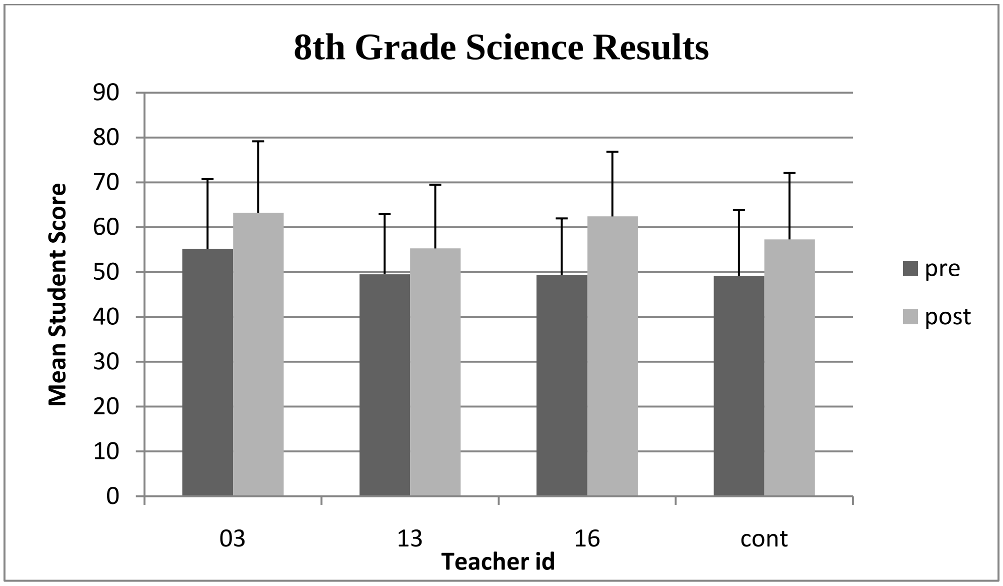

Figure 3. Mean Pre and Post Test Scores with Standard Deviation for 8th Grade Science Students.

7th Grade Students of Mathematics and Science

Students of all four 7th grade mathematics teachers took the mathematics pre and post tests. Likewise, students of all three science teachers took the science pre and post tests. However, two of the 7th grade science teachers were not included in the analysis because scores on the students' tests could not be matched to a pretest. Results of the mathematics and science students are shown in Table 16 and graphically depicted in Figures 4 and 5.

Grade 7 Mathematics

The mean student mathematics pre test scores ranged from 31% (s=15.06) to 51% (s=21.8). The post test scores ranged from 38% (s=17.02) to 67% (s=17.94). Students of teacher 09 had the highest mean pre and post test score, whereas, teacher 06 had the highest percent growth.

Table 16. Students' Pre/Post Results for 7th Grade Mathematics and Science

Teacher	Mean Pretest score	Standard Deviation	Mean Post Tests Score	Standard Deviation	Percent Growth
Mathematics					
08-06	34	13.9	53	14.1	36
08-09	51	21.7	67	17.9	24
08-10	41	14.1	48	17.5	14.6
08-17	31	15.1	38	17.0	18
Science					
08-01	50	15.9	55	15.8	9.1
08-04	46	13.4	51	14.3	9.8
08-19	29	13.9	41	11.3	12
08-08	–	–	–	–	–
08-15	-	-	-	-	-

The 7th grade mathematics students are depicted graphically in Figure 4. The results show a positive trend in improvement across all the 7th grade teachers, however, the standard deviation for the pre and post test scores overlap for each teacher. This may suggest there was no significant improvement on the student post test. However, the standard deviation does not overlap for students of teacher 06 suggesting significant improvement on the post test.

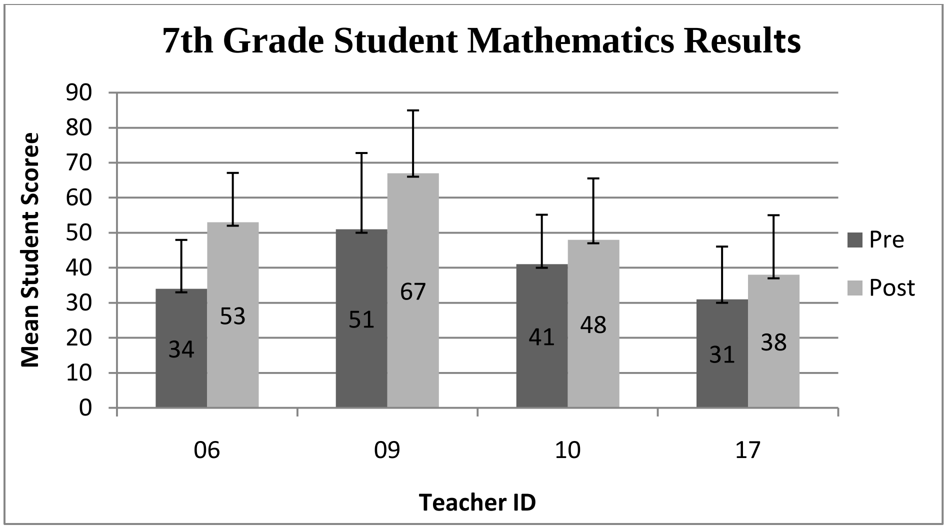

Figure 4. Mean Pre and Post Test Scores with Standard Deviation for 7th Grade Mathematics Students.

Grade 7 Science Students

Results for the 7th grade science teachers are summarized in Table 16 above and also shown graphically in Figure 5. The mean pretest scores ranged from 29% (s=13.9) to 50% (s=15.8) and post tests scores ranged from 41% (s=11.3) to 55% (s=15.8). The mean percent growth was 10.3%. Students of teacher 01 scored the highest on the pre and post test. Students of teacher 19 scored the lowest on the pre and post tests; however, they had the highest percent growth. Figure 5 shows a positive trend of improvement on the post test scores. The standard deviation within each sample overlaps the differences between samples which may suggest there is no significance difference between the pre and post tests.

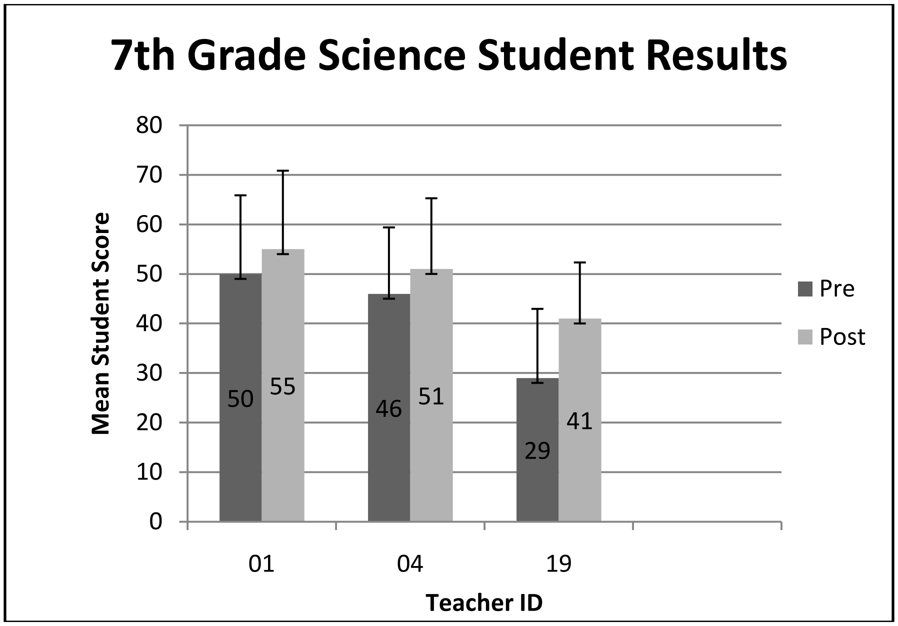

Figure 5. Mean Pre and Post Test Scores with Standard Deviation for 7th Grade Science Students.

Grade 6 Students of Mathematics and Science

All students of the 6th grade mathematics and science teachers took the pre and post tests. Results from 6th grade mathematics and science are summarized in Table 17. The mean pretest score on the mathematics pretest was 35.3 and the mean post test score was 45.9 (s=25.6). The mean pretest score on the science pretest was 39.1 (s=13.2) and the mean post test score was 45.4 (s=16.4). The percent growth on the post test was 10.6.

Table 17. Students' Pre/Post Results for 6th Grade Mathematics and Science

Teacher	Mean Pretest score	Standard Deviation	Mean Post Tests Score	Standard Deviation	Percent Growth
Mathematics					
08-14	35.3	15.6	45.9	25.6	10.6
Science					
08-05	39.1	13.2	45.4	16.4	6.3

Results from the 6th grade mathematics students are graphically shown in Figure 6. Students improved on the post test, however, the standard deviation overlaps with the sample between the pre and post tests. This may suggest that the improvement in post tests scores is not significant.

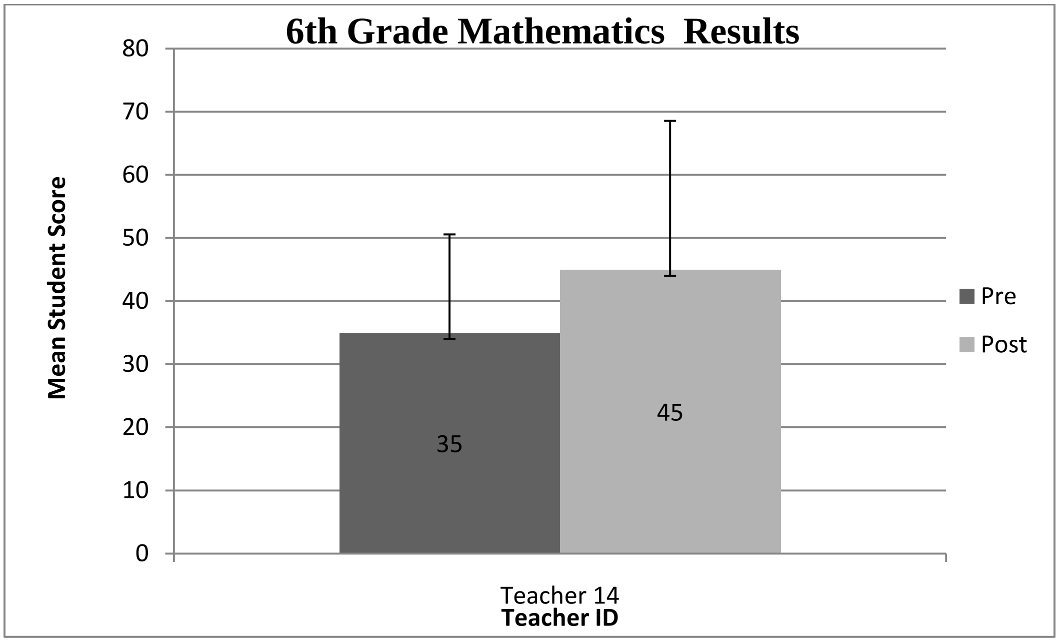

Figure 6. Mean Pre and Post Test Scores with Standard Deviation for 6th Grade Mathematics Students.

Results from the 6th grade science students are shown in Figure 7. Students of the 6th grade teacher improved on the post tests. The standard deviation overlaps between the pre and post tests which may suggest the improvement is not significant.

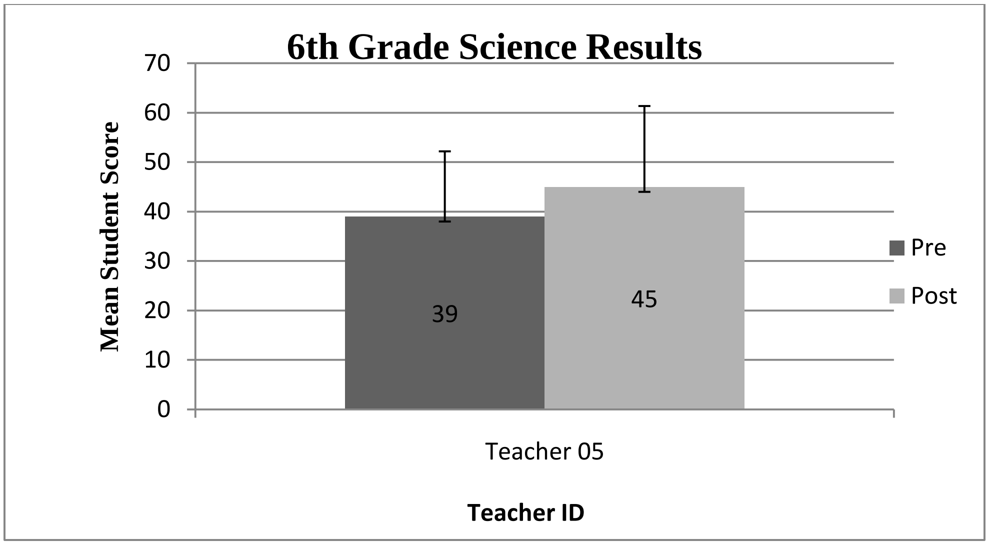

Figure 7. Mean Pre and Post test Scores with Standard Deviation for 6th Grade Science Students.

Grade 5 Student Mathematics and Science

The student data collected from the 5th grade mathematics and science teachers were not used in the analysis because pretests could not be matched with the post test.

Student TAKS

Student achievement in the State of Texas is measured by the Texas Assessment of Knowledge and Skills (TAKS). One measure of student learning is through TAKS scores. The % Met and % commended are performance descriptors that are used to describe how well students perform on a particular TAKS test (TEA, 2010). The science TAKS test is administered to students in 5th and 8th grades. Therefore, out of the 20 teachers that participated in the PD, only 14 teachers had returned TAKS scores for their students (Table 18). The mathematics TAKS is administered to students every year beginning in the 3rd grade. Teacher 08 did not submit scores because this teacher taught 7th grade science 2007 and 2008 academic school year. Teacher 05 and 17 did not submit scores from 2007 and 2008 because they were new teachers for 2008 academic school year.

Table 18. Teachers' Student TAKS Scores with % Commended and % Met.

Participant	Grade and Content	2007 - 2008		2008-2009	
		% Met	% Commended	% Met	% Commended
08-03	8th Grade Science	49	9	83	10
08-13	8th Grade Science	83	37	72	22
08-16	8th Grade Science	97	87	100	97
08-18	8th Grade Science	70	22	79	27
08-02	8th Grade Math	87.5	5	86	2
08-07	8th Grade Math	100	78	97	13
08-20	8th Grade Math	66	3	33	0
08-01	7th Grade Science	-	-	-	-
08-04	7th Grade Science	-	-	-	-
08-08	7th Grade Science	-	-	-	-
08-08	8th Grade Science	-	-	33	0
08-19	7th Grade Science	-	-	-	-
08-06	7th Grade Math	85	10	57	33
08-09	7th Grade Math	85	24	-	-
08-10	7th Grade Math	92	0	73	1
08-17	7th Grade Math	-	-	93	69
08-05	6th Grade Science	-	-	-	-
08-14	6th Grade Math	100	74	82	35

Table 14. (Continued) Teachers' Student TAKS Scores with % Commended and % Met

Participant	Grade and Content	2007 - 2008		2008-2009	
		% Met	% Commended	% Met	% Commended
08-11	5th Grade Science	75	27	74	18
08-12	5th Grade Math	85	45	79	26

TAKS scores of individual teachers over one year can reveal only weak trends. Therefore, the TAKS data that the funding agency requires does not allow meaningful analysis. However, principals typically accept a range of points depending on the school or the teacher. For example, a school may only gain one or two points but if these points help the score move from a low category to higher score it may be significant to the principal. A teacher may also have practical significance especially if the teacher has a history of continued improvement.

CHAPTER V

DISCUSSION

Teachers

Content Knowledge

Transcript Analysis

Effective instruction is dependent upon deep conceptual understanding and use of appropriate content pedagogy by the teacher (Basista & Matthews, 2002; Czerniak, 2007). Integrated science and mathematics lessons, when taught effectively, can lead students to conceptual understanding of both disciplines, promote student learning, and lead to a greater opportunity for problem solving (McBride & Silverman, 1991, Pang & Good, 2000; Czerniak, 2007).Without the conceptual understanding of both disciplines, students can become frustrated and the learning objective not achieved (Czerniak, 2007). There are varying recommendations of how much course work is needed for a teacher to have an adequate knowledge base to be an effective teacher. Using either the criteria of a typical minor or 24 hours of coursework, the transcript analysis revealed that half of the mathematics and science teachers lack the necessary college hours to be able to sufficiently teach a deeper and conceptual understanding of mathematics or science (see Table 3 for total results). According to the Texas State Catalogue, the hourly requirements to satisfy a minor are; Biology – 21 hours, Chemistry – 23 hours, Physics – 21 hours, Geology – 19 hours and Mathematics – 17 hours (p 59-60, Texas State

University-San Marcos Catalogue 2008-2010). Four of the 10 mathematics teachers had at least 17 credit hours in pure mathematics courses to meet the requirements of mathematics minor. However, if the Texas Higher Education Coordinating Board standard of 24 hours as a minimum level for competency is used, then only two who had a mathematics degree met that standard. The remaining eight mathematics teachers had a degree in a field other than their teaching assignment. Four of the 10 science teachers met the requirements for minor in biology, but none of them met the requirements for a minor in space science, or geology. The remaining 6 science teachers had a degree in a field other than their teaching assignment. For example, teacher 19 who taught Grade 7 science had a BS degree in photography/applied sciences with a minor in history.

Certification Routes

Currently, there are generally three different routes in which an individual can obtain a teaching certificate in the State of Texas.There are undergraduate degrees that include teacher certification. However, as a post baccalaureate or graduate student, one can become certified through either university-based traditional or Alternative Certification Programs (ACP) or through non-university-based ACP programs. The range of rigor is wide and the requirements are substantially different because the Texas Higher Education Coordinating Board allows a wide range of flexibility with an “outcomes based” philosophy where the only measure of competency is whether or not the candidate can pass a 60 item multiple-choice test. Non-university ACPs are less rigorous than university-based programs. For example, some ACPs have lower course work requirements or do not require any GPA (Baines, 2010). In Texas, alternative program such as I-Teach, have few standards or requirements except having a degree in any field

(Baines, 2010). Additionally, depending on the ACP, the content hour requirement can range from zero hours of credit to as high as 30 hours of credits (Baines, 2010). Student teaching in many non-university ACPs is not required. Most new ACP teachers obtain a generalist certificate. Only 3-4% of ACP science teachers have a major in their teaching field (Baines, 2010). Half of the teachers who participated in this project received their certification through non-university-base ACPs. Application to the mix program required teachers to submit their teacher certificates (see Table 1).

Pre and Post Test Results

Mathematics

The lack of significant gains in mathematics may have been due to both courses were science led. Sixty percent of the mathematics participants scored at least a 70 percent on the pretest, three of which scored a 90. The scores on the pretest were higher than expected (see Table 5). The broad range of scores on the pretest (60-90) may have been due to the diverse educational background of the mathematics participants (0 – 30 hours of mathematics coursework). All of the mathematics teachers either improved or maintained the same score on their post test except for teacher 06 and teacher 11. Teacher 06 had a pretest score of a 90% and a post test score of 85%. This teacher was certified in his teaching assignment, but received his certification though alternative certification with no student teaching. Also, this teacher had to leave the summer institute early because of a tropical storm in the Gulf of Mexico, but this teacher was able to take the post test at the first AY session. However, the first academic year training was held during the month of September, almost two months after the summer training. Teacher 11 was a Grade 5 mathematics teacher who received university based generalist certification which included student teaching, had only three credit hours of mathematics. All of the science teachers improved or maintained their pretest score except for one teacher; teacher number 03. This teacher received undergraduate and a master's degree from an institution in the Philippines, but was alternatively certified with no student teaching in the United States. Additionally, English was not her first language. Overall, the mathematics teachers had higher means on the pretest (75%) and post test (79%) than the science teachers pretest (65%) and post test (70%). Neither the mathematics nor the science teachers had statistically significant gains in mathematics. The lack of significant gains made by the science and mathematics teachers may have been a reflection on the time spent learning mathematics during both courses. Because both courses were science led, the majority of the time was spent on science learning and, therefore, an inadequate amount of mathematics instruction occurred to improve the science and mathematics teachers' knowledge in mathematics.

Space Science

Space science content knowledge was also measured via pre and post tests. The analysis was conducted on the cohort as a group and between mathematics and science teachers separately. The results revealed significant gains for participants both as a group and mathematics and science teachers separately. Greater gains were expected from the mathematics participants on the space science post test because only one of the mathematics teachers had a course in space science except. None of the mathematics or science teachers scored at least a 70 on the pretest. The science teachers' mean scores on the pretest (45) and post tests (57) were higher than the mathematics teachers' pretest (27) and post tests (54) which were expected. All of the participants maintained their score or improved on the post test except for one science teacher (Teacher 03). This is the same teacher who scored lower on the mathematics post test. Significant gains on the post test suggest the teachers had very little knowledge in space science and the course was successful in deepening their content knowledge in space science.

Geology

Geology content knowledge was measured via pre and post tests. As expected, none of the mathematics teachers scored at least a 70 on the geology pretest and, only three (teachers 13, 18, and 19) out of the ten science teachers scored at least a 70. Teacher 13 received her certification through a university-based program with student teaching and had 11 credit hours of geology coursework. Surprisingly, teachers 18 and 19 were both alternatively certified with no student teaching and no geology coursework. Teacher 18 had a Bachelors degree Molecular Biology and Teacher 19 had a degree in Photography and Applied Sciences. The results for the science teachers were not surprising considering that the content background for the science teachers was extremely low in earth science. All of the mathematics and science teachers improved significantly on the post test which is a reflection of the conceptual understanding the teachers gained during the summer training. The geology field trip during the summer institute may have contributed to the gains by the mathematics and science teachers because they applied the knowledge they learned in the classroom in a field setting. The teachers collected and identified the three types of rock; igneous, metamorphic, and sedimentary at various sites in Central Texas for their geology teaching collection.

Instructional Skills

Overall, participants realized how effective best-teaching practices, such as the use of manipulatives and inquiry, can be with their own learning, as well as student learning. Through teacher reflections, teacher interviews, and principal interviews, teachers and principals, revealed they discovered and agreed how difficult concepts, such as phases of the moon should be taught with manipulatives. Not only did teachers report during AY sessions that they incorporate more manipulatives in their instruction than before the training, the use of manipulatives was evidence during observation of participants' classes.

Inquiry is another best-practice that was modeled during the *Mix It Up* PD. An effective inquiry lesson takes time to plan, but it can increase student engagement and learning (Smith et al. 2007). Participants acknowledged how a good inquiry lesson can lead to better understanding of science concepts. Teachers identified barriers encountered when trying to implement inquiry as a best practice into their classroom. These barriers included administrative support, and time to plan inquiry lessons. Another barrier emerged from the qualitative instruments was teacher efficacy. Teacher self efficacy refers to a teacher's confidence in performing a certain task correctly (Smith et al. 2007). Teachers beliefs that they are able to teach with inquiry can influence their ability to implement inquiry into their instruction. These findings are aligned with previous research by Smith et al. (2007). Teachers who have a higher self-efficacy than a teacher with a lower sense of self-efficacy are more likely to incorporate inquiry learning in their lesson planning (Smith et al. 2007).

A teacher's lack of background in inquiry and content knowledge has also been suggested as a barrier to implementing inquiry (Smith et al. 2007). The third research question of the *Mix It Up* PD was to measure the effectiveness of standards-based instruction, such as inquiry, and how it can improve student learning. Through teacher interviews, summer reflections, teachers reported they realized the benefits of using inquiry lessons; however, these changes take time to implement into classroom teachings. Because teachers improved their content knowledge, it is expected that they will incorporate inquiry in their teachings.

Integrated Lesson Implementation

One of the original goals of the *Mix It Up* PD was to instruct teachers how to use and implement correlated lessons in their teachings. Based on previous research (Gloyna, 2008), results have shown that it is not practical to expect teachers to implement CSM in their teachings. The CSM Model requires lessons to be taught by a single teacher that has conceptual understanding of both subjects or lessons must be taught for conceptual understanding. Therefore, the lesson must be taught by a science teacher and a mathematics teacher. Because of this, the CSM has transformed into a PD model that is used to train teachers how to integrate mathematics and science.

Overall, the teachers had a greater understanding of how to integrate mathematics and science. However, the teachers identified several barriers that impact their ability to integrate mathematics and science. The barriers identified by teacher interviews and observations, daily reflections, and participant feedback, were lack of time to plan, joint planning time with their partner, administrator support, and pressure to teach TAKS objectives. Teachers also expressed concern about teaching a subject for which they were not prepared to teach. Meeting with their partner might help to reduce this problem, but mathematics and science teachers are often on different schedules and cannot meet to discuss lessons. These barriers identified by cohort IV align with previous research conducted by Gloyna, 2008; Huntley, 2008; Johnson, 2006; Stinson, Harkness, Meyer, Stallworth, 2009.

Teachers do not have enough confidence integration as a means to improve student performance; thus, they focus more on teaching TAKS objectives. There have been two studies with evidence that supports mathematics student learning is improved from integrated lessons (Judson & Sawada, 2000; Yasar et al. 2006). Another barrier identified by teachers, often they are required by the administration to temporarily stop teaching their current lessons to support TAKS testing. For example, at one particular campus, a 7th grade teacher was required to temporarily refrain from teaching science to tutor students for an upcoming Reading and Mathematics TAKS. Other teachers revealed that they are required to completely stop teaching six weeks before TAKS to prepare students for the mathematics TAKS. Cohort IV teachers shared that the integrated lessons seemed to have a positive effect on student engagement and the teachers expressed an interest and would move towards more integrated lessons.

Students

Student Reflections

A student reflection questionnaire was given to the students after AY teacher interviews. Student reflections revealed several themes. Most students were positive and enjoyed an integrated lesson. Some were surprised and amazed how the two subjects are related. For example, they did not understand why they were learning mathematics in a science class or why science was presented in a mathematics class.

Student Content Knowledge

TAKS

The goal of most professional development is to have a positive effect on student content knowledge. Student mathematics and science content knowledge was measured using student and pre and post tests and TAKS scores. However, the teachers were asked to submit their overall science scores instead of the subsection on earth science. Therefore, using the overall TAKS scores may not have measured student performance on the Earth Science Objective which was the focus of the professional development. Student TAKS scores are used by the State of Texas to track student learning. Most importantly, the fourth research question of this study was to measure if the *Mix It Up* PD had an effect on student content knowledge and if the training had any effect on student TAKS scores. However, it is difficult to identify anything other than trends using science TAKS scores for several reasons. Some tests are not administered to students every year. The science TAKS is administered to students only during their 5^{th}, 8^{th} and 10^{th} grade years. On the other hand, the mathematics TAKS test is administered to students every year. Moreover, individual students would have to be tracked over the years to link TAKS scores with other factors such as a particular teacher. Therefore, it is difficult to identify trends in the science data, so it is necessary to review student scores of teachers who participated in the program prior to the PD and the AY after training. Fourteen of the 20 participants submitted their student scores prior to the *Mix It Up* PD. Two of these teachers did not have scores because they were new teachers. Three teachers taught 7th grade science and, therefore, did not have scores to submit and remaining teachers chose not to submit their student scores. Longitudinal individual student data is necessary to identify trends and patterns in student learning. One of the limitations to this research is the lack of longitudinal student data. It would also be beneficial to have student scores of teachers who did not participate in the *Mix It Up* PD (control).

Students of teachers at one particular campus (Natalia ISD) scored exceptionally well on their mathematics and science TAKS. However, this grade 8 science class scored well consistently for three years on the TAKS. It is difficult to determine how much of the *Mix It Up* Training can be attributed to student learning on TAKS. There are many different variables that contribute to student learning such as school administration, teachers, and parental involvement (Guskey & Sparks, 1996) and it is also difficult to determine what the greatest factor that contributes to student learning. However, after review of students scores of teachers before they received training reveals that students did just as well on the TAKS even though these teachers had not participated in the PD. Interviews revealed that one particular teacher at this particular ISD completely stops teaching new material and dedicates six weeks in preparation for the TAKS in mathematics. Other teachers revealed that they stop teaching to help prepare students for the TAKS in subject areas other than science or mathematics. It appears these factors may have contributed to this schools success on the TAKS.

Student Pre and Post Tests

Previous *Mix It Up* Correlated Science and Mathematics PD evaluation used only student TAKS data to measure student learning. As previously mentioned, it is difficult to draw conclusions based on TAKS data because longitudinal data is required. It is assumed that there is a strong relationship between professional development and student learning (Guskey & Sparks, 1996; Czneriak, 2007), however, efforts to define this relationship have been met with little success (Guskey & Sparks 1996). The fourth research question of the *Mix It Up* Professional Development Model was to measure if the teacher training affected student content knowledge. It is not certain if integration affects student content knowledge, but research has suggests that integration can lead to a deeper conceptual understanding of mathematics and science (Berlin & White, 1991; Basista & Matthews, 2002; Czerniak, 2007). It was expected that the 8th grade students of the mathematics and science teachers would not show significant improvement on the post test because they would have greater background knowledge in mathematics and science. Whereas, it was the remaining grades in mathematics and science would show significant improvement on the mathematics and science post tests.

The student results from the analysis were not expected. Students of teachers 06 and 16 were the only classes that appeared to have significant improvement on the post test. Teacher 06 was a 7th grade mathematics teacher who received through an alternative certification but has a degree in electrical, as well as mechanical engineering. This teacher during an academic year interview, the he attempts to integrate his lessons at least once a week. He also shared that he tries to incorporate mathematics manipulatives that was modeled during the PD into his lessons. These factors may have contributed to his students' success on the post test. Teacher 16 was an 8th grade science with alternative certification with a degree outside his teaching assignment. During a teacher interview, the teacher shared that he does not attempt integration in his classroom, but uses hands-on activities such as models while teaching seasons and phases of the moon.

The remaining students of the mathematics and science teachers showed improvement on the post tests, but the improvements were not significant. Similar results showed for the control. Several reasons may have contributed to these unexpected results. Teachers were asked to provide an identifier on the scantrons so that a pretest could be matched with a post test. However, six of the teachers did not use an identifier to match the pretest with the post tests at the end of the year. Because of this, students of six of the 20 teachers were not included in the analysis. Additionally, some students did not take the pre or post tests test or may have been absent the day the test was administered. These scantrons of students that could not be matched were not included in the analysis. These issues were not under our control in this research. To effectively measure and compare student knowledge, all students from all grade levels in mathematics and science should be included. Additionally, to effectively measure the significance of the treatment, a control with similar demographics should be used at each grade level in mathematics and science.

Other factors that may have influenced the outcome of the post tests was that the test was administered mid May after the students were administered the TAKS test. It is highly likely that the students were not motivated to take another test at the end of the year. Teachers were asked to provide an incentive to motivate the students. Even though the 5^{th} grade science mathematics and science students were not included in the analysis, a 5^{th} grade teacher expressed that most of his students did not try because the students felt the questions on the science and mathematics tests were too hard. He reported the only students who put forth an effort were the gifted and talented students in the class.

All of the questions on the mathematics test were taken from 8^{th} grade state released tests. The 8^{th} grade state mathematics tests are not cumulative and cover content learned during the 8^{th} grade. Therefore, the rigor of the test was too difficult for the lower grades and did not effectively measure student content knowledge. On the other hand, the questions on the science test came from 8^{th} and 5^{th} grade released test items. The 8^{th} grade test is a cumulative test containing items on concepts that were learned during the 6^{th}, 7^{th}, and 8^{th} grade years. The 5^{th} grade test is also cumulative and consists of science concepts learned during the 3^{rd}, 4^{th}, and 5^{th} grades. However, the test was not constructed so that the easier 5^{th} grade items were located at the beginning of the test thereby contributing to a grade 5 student effort. The more difficult questions should have been placed towards the end of the test to prevent the younger students from becoming discouraged at the beginning of the test.

Conclusion

There were four research questions which framed this study: 1) Did teachers' content knowledge and skills increase in space science, geology, and mathematics? 2) What extent did teachers implement integrated science and mathematics lessons? 3) What extent did the Mix It Up Professional Development improve the instructional skills of the middle school science and mathematics participants? 4) Did student achievement increase in science and mathematics? The PD was successful in meeting three of the four research questions and number of implications can be drawn from the program evaluation of the *Mix It Up* CSM PD. These implications provide a framework for future *Mix It Up* PD.

The teachers significantly increased their content knowledge in space science, and geology, improved their instructional skills, and adapted an integrated approach to lesson planning. They also realized that a successful integrated lesson requires a conceptual understanding of at least one subject, either mathematics or science. There were no significant gains in teacher mathematics content knowledge. Also, results from the student analysis appears that students of only one 8^{th} grade science teacher and one 7^{th} grade mathematics teacher had significant improvement. Even though students did not improve significantly in mathematics and science content, these results can help design future professional development that will measure student achievement effectively.

Strategies to Improve Professional Development

This cohort of mathematics teachers reported they were not satisfied with the amount of mathematics taught during the summer institute. It appears that there was not enough time spent during the summer institute learning mathematics. Because both summer courses were science led, science teachers were not taught enough mathematics for them to significantly improve their mathematics content knowledge. To increase mathematics and science teacher mathematics content knowledge, future *Mix It Up* PD should focus on providing more mathematics content in the courses.

There are several changes that could be made to the PD to encourage teachers to adapt an integrated approach to mathematics and science teaching. Currently, all teachers are required to be observed at least once and these observations were scheduled in advance. Additional unscheduled observation and interviews of teachers would also help and encourage teachers to keep thinking about integrating their lessons. Other professional development programs require teachers to log their lessons in a portfolio

(Basista & Matthews, 2002). This may also encourage teachers to think about integrated lessons and provide teachers an opportunity to reflect on their lessons as well as future integrated lessons.

Instructional Skills

Currently, interviews and observations are scheduled after the teachers have received training from the summer institute. To measure how well teachers are implementing effective teaching pedagogy, it is essential to observe and interview teachers before the summer institute and once again afterwards. Principals also need to be part of the summer institute training as well as the AY sessions. Teachers need the support of their administration to achieve integration in their classroom. Questionnaire should also be given to teachers, as well as, principals to measure how much teachers perceive they integrate at that point.

Student Data

Despite the student data revealed no significance; there are several ways to improve future studies. This research utilized only one control teacher. Whereas, an equal number of control teachers as experimental design is desirable with equivalent groups at each grade level and each subject area. The instrument used to measure student content knowledge in mathematics was not effective. The test was geared towards 8^{th} grade content knowledge which left students in the lower grades discouraged. To effectively measure mathematic content knowledge, a test needs to include a range questions at each grade level or a separate test should be used for each grade. Additionally, a strong incentive should be given to the students to encourage students and keep them interested in doing well on the test.

The *Mix It Up* Professional Development emphasizes the importance of integration and trains teachers how to integrate mathematics and science. However, there are outside barriers that are beyond the realm of this professional development that must be overcome before integration to occur. One of these barriers include, sufficient empirical evidence that suggests integration improves student achievement, specifically TAKS scores. According to Meier, Nicol, & Cobbs (1998), integration of science and mathematics will not take place unless there is evidence that supports improvement in student performance. Another barrier is the lack of the national, as well as state standards, for integrated mathematics and science. The Standards guide curriculum, instruction and assess and therefore play a critical role in the classroom.

Interestingly, there was an impact on undergraduate students and graduate students who worked with the project. One undergraduate student as an inservice teacher later reported as she taught her own students, “I think some of the valuable things I learned were how to correctly integrate a lesson, the value to the students of a good inquiry lesson, and the one concept per lesson. It is so easy to get caught up and do more than one.” Additionally, it is important to fully understand what you are teaching.” In response to a mathematics lesson on fractions that utilized Cuisenaire Rods, a Ph.D. candidate at Texas State University reported, “I have seen students struggle so much with fractions and this seems like a great tool to help them learn. I'm sure I'll use what I learned today in teaching/tutoring future students.”

Changes in teacher practices take time and it is difficult to expect teachers to change their practices within a short amount of time. Requiring teachers to shift their teaching style and make many changes to their teacher style can set them up to fail.

Moreover, it is difficult to expect in-service teachers to adapt an integrated approach to their lessons especially if they have never been exposed to them. “Teachers are more likely to emphasize this connection in the middle school if they have participated in integrated methods courses.” (Koirala & Bowman, 2003). Therefore, as more preservice teachers are taught how to integrate, it is expected to see more teachers adapting an integrated approach to the teachings.

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