EVALUATION OF TEACHER PROFESSIONAL DEVELOPMENT

MIX IT UP: *CORRELATED SCIENCE & MATH*

INSTRUCTIONAL MODEL

THESIS

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ABSTRACT

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This study focuses on a version of the historically popular approach called "integrated science and math." Integrating science and math typically means making linkages between the two disciplines. Science uses math as a tool or way to teach science or math uses a science topic or phenomenon as an application of a math concept. The present study will evaluate a new instructional model of integrated science and math, Correlated Science and Math (CSM). This model is unique because the concepts in each discipline are taught with two fundamental goals: (1) acquisition by the learner of conceptual understanding of both science and math, not just as a tool or an example and (2) use each discipline's proper language. Therefore, whether the lesson or course is science or math led, to be considered as using a CSM model both goals must be met. This study will evaluate certain components of the CSM professional development program especially designed for middle school science and math teachers. The study consisted of three cohorts of inservice teachers within the study time frame from the summer of 2006 to the spring of 2008. The mixed methods research design which has components of both qualitative and quantitative elements was used to explore the research questions. The data consisted of inservice teachers' demographics including analysis of transcripts, certification and current teaching assignment, pre and posttests results, teacher evaluations of various components of the CSM program, and classroom observations. The data analyses suggested that the teachers acquired new knowledge in the science content areas more than in the math content areas, as a result of the CSM professional development program. The teachers gained a better understanding of CSM and were able to adopt either a CSM or integrated mode in the classroom.

Key words: Correlated Science and Math, integrated science and math, mixed methods, cohorts, inservice science and math teachers

CHAPTER I

INTRODUCTION

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

The inadequate achievement of American students in science and math at the state, national and international levels, is a great concern in the United States as reported in Rising above the gathering storm: Energizing and employing America for a brighter economic future (National Academies, 2007) and in Foundations for success: The final report of the National Mathematics Advisory Panel (National Mathematic Advisory Panel [NMAP], 2006). Of equal concern to American Science, Technology, Engineering, and Mathematics (STEM) stakeholders is the inability to meet an increasing need for a workforce sufficiently educated in science, math, and technology (National Science Foundation [NSF], 2007). Both the science and math education communities attempt to address these concerns via their standards, that is the National Science Education Standards (National Research Council [NRC], 1996) and Principle and Standards for School Mathematics (National Council of Teachers of Mathematics [NCTM], 2000). For science and math educators to achieve the goals of the standards, important changes in teaching practices will be required (Goldenberg & Gallimore, 1991).

"Teaching and learning practices must be aligned with standards and outcomes" (Crates, 1997 p. 16). More specifically, the National Science Education Standards (NRC

1996) and the Principle and Standards for School Mathematics (NCTM, 2000) advocate that reforming science and math education requires changes in what and how science and math are taught. For these changes to occur a different approach is needed in teacher preparation and professional development practices. Hence, this study focused on the evaluation of Correlated Science and Math, which is an expanded version of the historically popular approach called "integrated science and math." Integrating science and math typically means making linkages between the two disciplines. This, usually, occurs with science using math as a tool or way to teach science or math using a science topic or phenomenon as an application of a math concept or a way to interest students in learning math.

In science and math education, there exists a range in science and math lessons or courses that spans from a "pure science" lesson/course which contains no math to a "pure math" lesson /course which contains no science. In between there are various amounts of integration between science and math (see Figure 1).

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Science with no math	Science w/math	Math w/science	Math with no science

Figure 1: Integrated Science and Math

A "pure math" lesson/course does not use any science. At the other end of the spectrum, a "pure science" lesson or course has no math in it and is often called a "conceptual science" course. In between these two extremes is integrated science and math, where science uses math as a tool such as solving a genetics problem or to actually teach the science concept such as using calculations to determine a rate such as speed. Conversely, the integrated math with science would use science as examples to explain math concepts or to employ the science to reinforce students' interest in math or to enable them to recognize the usefulness of math.

This new model of integrated science and math that was first identified by West and Tooke (2001) and termed "Correlated Science and Math" (CSM) and later modified by West and Vasquez-Mireles (2006), West, Vasquez-Mireles and Coker (2006) and Vasquez-Mireles and West (2007). The CSM model is unique in that it links science and math in a way that is different from the traditional integration as described earlier. It is illustrated in Figure 2.

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Science	Science w/math	CORRELATED SCIENCE & MATH	Math w/science	Math

Figure 2: Correlated Science and Math

In the CSM model, the concepts in each discipline are taught with two fundamental goals: (1) teach for conceptual understanding, not just as a tool or example and (2) use the discipline's proper language. Therefore, whether the lesson/course is primarily focused on science, or primarily focused on math, both goals must be met to be considered as using CSM model. Further, CSM is both a curriculum and an instructional model. In the purest form of a CSM model the science and math concepts are almost equally weighted and one cannot discern whether the lesson has a science or math focus.

The CSM model can be constructed as individual lessons or as a series of lessons in a course. As previously stated, CSM lessons/courses can be science or math led. For example, a CSM science-led course would include math lessons that teach for conceptual understanding in math and acquisition of the proper math language by students as well as conceptual understanding of science concepts. To further illustrate this, a physics-led

CSM course, might have a lesson on "position" that would teach physics' concepts of position, distance, and displacement. Concurrently, the "position" lesson would also include teaching the math concepts of coordinate graphing and measurement. In a maximally correlated course one could not easily distinguish if the course is a science or a math course, except perhaps by the title or the course number.

Mix It UP: CSM Goals

Although both the National Education Science Standards (NRC, 1996) and the National Math Standards (NCTM, 2000) advocate linking science and math, there are no suggestions on ways in which the connections should occur. However, the traditional linkage is "integration" as previously described. Science has historically integrated more math than math has integrated science. Modern science uses math extensively through making calculations, solving problems, or conducting statistical analyses. Science majors learn to use math, but they do not necessarily understand mathematics at the conceptual level. Almost every college science degree has math requirements. In contrast, modern math degree plans may have a science requirement ranging from 7-8 hours in the natural sciences, not necessarily in the same science. Hence, middle school science or math teachers who have a math or science degree are not likely to have a conceptual understanding of each other's discipline.

Further, it is rare that middle school science or math teachers have a math or science degree because they are typically trained in elementary generalist education (grades 1-8). It is for these reasons that the Mix It Up: CSM program provides science and math teachers with opportunities to deepen their content and pedagogical knowledge in the context of high quality instructional materials to better prepare teachers. It is expected that participants of this program will change their instruction in ways advocated by the national standards and increase professional dialogue and collaboration between science and math teachers. Additionally, improved instruction is predicted to, in turn, lead to higher student achievement in science and math. Therefore, the CSM program's goals are to: (1) provide intense and sustained correlated math and science content knowledge and skills to preservice teachers not yet certified and inservice teachers, certified and currently teaching; (2) recruit, strengthen and retain middle school math and science teachers; and (3) improve students' (grades 5-8) achievement in science and math.

Rationale of the Study

Although the practice of linking science and math curricula to improve student performance is intuitively useful and valuable (West & Took, 2001) and supported by both math and science national standards (NCTM, 2000; NRC, 1996), there is a lack of strong research support for the CSM model. Indeed, limited studies (Judson & Sawada, 2000) provide evidence that the integration of science and math content and/or process improves student achievement. No replication studies exist, or statistically significant results exist and there is no research that focuses on middle school students. Therefore, due to the limited research in the science and math integration area additional studies are needed. The research goal of this study was to evaluate certain components of Mix It Up: CSM professional development program. Within that research goal are the following four objectives: (1) increase inservice and preservice teachers' content knowledge; (2) improve teachers' pedagogy with an increase in the use of science education best practices; (3) enable teachers' to successfully use CSM innovative strategy in their classroom instructional practice; and (4) to improve student achievement in science and math.

Research Questions

1. As a result of participating in the Mix It Up professional development program, did inservice teachers' content knowledge and skills increase in science and math?

2. To what extent did the inservice teachers use the recommended correlated science and math strategies?

3. What were the perceptions of teachers as they implemented CSM learning in the classroom teaching practice?

4. Did the Mix It Up teachers' students improve in their understanding of science and math?

CHAPTER II

LITERATURE REVIEW

Evaluation

"Evaluation is defined as systematic investigation of the worth or merit of an object" according to the Joint Committee on Standards for Educational Evaluation (Sanders, 1994, p. 3). Assessment by contrast is the "the act of determining the standing of an object on some variable of interest…" (Sanders, 1994, p. 203). There are three types of evaluation: personnel evaluation, student evaluation and program evaluation. Personnel evaluation assesses how individuals perform the responsibilities of their work, and it provides direction to improve individual performance. Student evaluation assesses student achievement and provides direction to improve student academic achievement. Program evaluation assesses the quality of program activities and provides direction for their improvement (Sanders, 1994). The present study specifically focuses on the evaluation of a secondary school teachers' professional development program, Mix It Up: CSM. The effectiveness of this study was assessed to determine how well the program met its goals in order to provide direction for future professional development in the Correlated Science and Math (CSM) model.

Program Evaluation

Effective program evaluation promotes continuous program improvement and ensures program accountability (Kutner, Sherman, Tibbetts, & Condelli, 1997).

Education and training programs are evaluated in order to determine their quality and gain direction for improving them. Program evaluation standards intend to help evaluators, university professors, and staff developers to design, conduct, and assess program effectiveness (Sanders, 1994).

Professional Development

Professional Development (PD) is an intentional, ongoing and systemic process with designed activities that enhances the professional knowledge, skills, and attributes of educators, which in turn improves student learning (Guskey, 2000). The definition of professional development can be expanded to include "the sum total of formal and informal learning experiences throughout one's career from preservice teacher education to retirement" (Fullan, 1991, p. 326). Professional development programs are intended to improve teachers' skills by providing them with techniques that positively impact student achievement (Shaha, Lewis, O'Donnell, & Brown, 2004). Similarly, some educators (Guskey, 2000; Guskey & Huberman, 1995; Guskey & Sparks, 1996) have advocated that the ultimate goal of professional development is to contribute to improved classroom practices and ultimately to higher student achievement.

Professional Development Program Evaluation

In this age of accountability as students are expected to meet higher standards that will enable them to compete in the global market, professional development is very important in order to improve student achievement (Guskey, 2002; National Academies, 2007). Equally important is ensuring that the professional development accomplishes its objective via program evaluation. However, there are few program evaluations that provide data showing the effects on both teachers and students, particularly on student achievement. The impact of professional development on teachers, students, and schools is usually not documented. As a result, evaluations of professional development have typically been an overlooked component of the education process (Kutner et al., 1997).

However, with the enactment of No Child Left Behind (NCLB) legislation of 2001 (U.S. Department of Education, 2004), there is significant pressure to find ways to support successful teaching and learning through effective professional development. Hence, to determine if there is any evidence of teachers' successful implementation of effective teaching strategies and student successes, standards-based evaluations must be incorporated within the professional development process (Kutner et al., 1997). A major problem with most professional development programs is the short duration of either one-half day or day long training which may or may not be sufficient to fulfill teacher professional development needs. There are seldom any subsequent follow-up sessions that will reinforce or enhance learned skills (Guskey, 2000). Thus, training without subsequent follow-up is insufficient to provide teachers with the content knowledge and content specific methods or pedagogical skills to improve student performance in general and more specifically to improve performance of low achieving students (Sparks & Hirsh, 2000). Hence, to improve education, especially in science and math, professional development training must be improved via program evaluation.

Professional and Staff Development Standards

Professional development is meant to improve teacher and student learning. Staff development helps educators keep abreast of emerging knowledge and skills so that they can continue to improve their conceptual and pedagogical content knowledge skills (Guskey & Huberman, 1995). According to Crandall, Eisemann, and Louis (1986) the success of PD is directly related to the magnitude of the advocated change. One cannot expect immediate positive results from the initial implementation of a professional development training program. Successful professional development is possible, but it typically occurs through successional stages. If a drastic change in teaching strategy is the goal of professional development, then the typical participant finds it difficult to adopt the new strategy quickly. Thus, successful professional development using a less familiar model would require an adequate time frame for a noticeable change to occur.

"A standard is a principle mutually agreed to by people engaged in a professional practice, that, if met, will enhance the quality and fairness of that professional practice" (Sanders, 1994, p. 2). Professional or staff development "standards" are defined as criteria for staff development that improves the learning of all students (NSDC, 2001). There are three different types of standards for staff development: "context", "content" and "process" standards.

The "context standards" requires staff development to improve the learning of all students to create learning communities and provide leadership and resources. Successful staff development organizes adults into learning communities whose goals are aligned with those of the school and district. The context standard addresses the need for skillful school and district leaders who guide continue instructional improvement. Lastly, the context standard addresses the issue of resources that are needed to support adult learning and collaboration. These resources in turn support teachers to enable them to make changes and develop new approaches for their classroom (NSDC, 2001).

The "content standard" provides criteria for staff development to improve the learning of students by preparing educators to support learning environments, and hold high expectations for their students' academic achievement. Effective staff development deepens educators' content knowledge and skills and research-based instructional strategies in order to assist students in meeting rigorous academic standards (NSDC, 2001). Additionally, effective professional development prepares teachers to use various types of classroom assessments appropriately (NSDC, 2001).

Like context and content standards the "process standards" also provides criteria for effective staff development that is based on student data such as standardized test, student work samples and student portfolios. This information is used to determine adult learning priorities, the success of the professional development program and the need for adjustment in the professional development program. Student learning will improve by preparing educators in how to apply research from the student data collection in making decisions about professional development goals and to use learning strategies compatible with the intended goal. In summary, by implementing the NSDC Staff Development Standards, the learning of all students will improve (NSDC, 2001).

Science and Math Education Professional Development

The science and math communities acknowledge the need for improved professional development and have made recommendations for its improvement. Science and math teachers need content-focused professional development training which will teach teachers how to help students learn important science and math concepts and processes (Loucks – Horsley, Hewson, Love, & Stiles, 1998). Professional development can also improve teachers' learning and students' performance (Basista & Mathews, 2002; Loucks – Horsley, Hewson, Love, & Stiles, 1996; Luft, 2001). Additionally, effective professional development training provides teachers with solid content knowledge and skills which prepare teachers to teach more challenging standards-based instruction, which helps students to understand important science and math concepts and principles.

Although the above studies support the idea that improving science and math teacher quality results in improved student academic achievement, the empirical evidence is limited on the features of effective professional development that improves students' performance. More studies that focus on science and math professional development is recommended to fill this research gap. More research should focus on the impact of professional development on teachers' acquisition of content and pedagogical knowledge and skills, subsequent teaching performance and its ultimate impact on student achievement (Lewis & Jeanpierre, 2006).

Additionally, to meet the needs of the 21st century, America's teachers will have to teach a range of "vastly different learners to master more complex skills and more challenging content" (Darling-Hammond, 1997, p. 4). Professional development is viewed as a central tool to educational reform to improve learning and achievement for all students (Elmore, 1996; National Commission on Teaching & America's Future [NCTAF], 1996; National Education Goals Panel, 2000; NMAP, 2007).

Science and Math Professional Development Impact on Teacher and Student Achievement

Effective math and science professional development training programs improve teachers' content and pedagogical content knowledge and skills, which in turn is predicted to improve student achievement in science and/or math. The literature supports the positive impact on teachers' knowledge, skills, attitudes and capability by professional development (Feazel & Aram, 1990; Frykholm & Glasson, 2005; Hill & Ball, 2004; Supovitz, Mayer & Kahle, 2000). Professional development programs based on hands-on, inquiry learning with a focus on science and math content and process improves teachers' attitudes toward learning science and math and increases their comfort level in teaching their students (Feazel & Aram, 1990). Further, Supovitz, Mayer, and Kahle (2000) examined the impact of professional development on teachers' attitudes towards inquiry based instruction and the use of this instruction in the science classroom. The finding suggests that intense and sustained training rather than single day sessions lead to changes in improved teaching practices. Finally, Hill and Ball (2004) found that content-focused professional development in math led to improvement in teachers' content knowledge.

Additionally, professional development plays an important role in improving teaching quality when teachers' learning activities are closely related to actual classroom practice. This ultimately makes a difference in student achievement (Haycock, 1998; Wenglinsky, 2000). In the Wenglinsky (2000) study, 8th grade students whose math teachers received PD in higher order thinking skills outperformed their peers by 40% on a grade level National Assessment of Educational Progress (NAEP, 2008) 1996 mathematics assessment. Similarly, students whose science teachers received professional development in laboratory skills outperform their peers by more that 40% on a 1996 grade level NAEP (2008) science assessment (as cited in Wenglinshy, 2000).

Further, Huffman, Thomas, and Lawrenz (2003) examined the relationship between secondary school teachers' instructional practice and student achievement in science and math. Two regression analyses were run, "one using the science and math teachers' scores on the curriculum and instructional scale as the dependent variable and the other using student state achievement test scores as the dependent variable (Huffman, Thomas, & Lawrenz, 2003, p. 381)." Both regression analyses used the types of professional development the teachers attended as the independent variable. This study revealed that the professional development for math teachers was significantly related to increased student math achievement. The study, however, did not report any relationship between the professional development and the students' science achievement.

Additionally, a 1998 study by Cohen and Hill found a positive relationship between teacher participation in a long-term curriculum workshop and students' scores on California's state mathematics assessment. Similarly, a recent study by Johnson, Kahle and Fargo (2006) suggests that the improvement of teacher effectiveness and subsequent student improvement in math and science was achieved through sustained and collaborative professional development. A general linear mixed model approach was used to assess change in student science scores at six, seven and eight grade levels on the Discovery Inquiry Test designed for a state systematic science education reform (Johnson, Kahle & Fargo, 2006). The finding suggests that there is a significant relationship between effective teaching and student science achievement.

Science and Math Integration

Science and math integration is a linkage between the two disciplines, where science is typically used in math as an example or phenomenon and math is used in science as a problem solving tool. There are at least four reasons for linking math and science (McBride & Silverman, 1991). First, math and science are closely related systems of thought. Secondly, science provides concrete examples of mathematical ideas and can improve math learning. Third, math can lead to in depth understanding of science concepts by quantifying and explaining relationships and recognizing patterns. Finally, science activities provide a basis for investigating and learning mathematics. Consequently, a number of national science and math education professional associations are united in their support for the integration of science and math teaching and learning (NCTM, 2000; NRC, 1996).

There is abundant literature that recommends integrating science and math (Berlin, 1990; Berlin & White 1992; Huntley, 1998; Lehman, 1994; Lonning & Defranco, 1994; McBride & Silverman, 1991; Watanabe & Huntley, 1998; Westbrook, 1998). According to this literature, teaching by linking science and math occurs in various degrees, ranging from math and science being totally separated to both of them being fully integrated. Integration of science with math in a more applied approach occurs as students gather, represent, and analyze numerical data to answer scientific questions (Chalufour, Hoisington, Moriarty, Winokur, & Worth, 2004). Additionally, when science and math are integrated in this way it provides a foundation and support for teaching science with math concepts. Huntley (1998) however, suggests a continuum of teaching science and math, in which one subject is of primary importance and the other supports, such as a science led or math led course.

However, despite a strong support for integration of science and math (NCTM, 2000; NRC, 1996) as a way to improve teacher and student achievement in these disciplines, there are limited empirical data to support this hypothesis (Huffman, Thomas, & Lawrenz, 2003). Therefore, there is a need for research on connecting science and math (Huffman et al., 2003; Douville, Pugalee, & Wallace, 2003; Frykholm & Glasson, 2005; West, Vasquez-Mireles, & Coker, 2006).

According to Lonning and DeFranco (1994) the results of science and math integration should be evaluated on the basis of students' and /or teachers' understanding of both science and math concepts. The physical separation of science and math instruction and a lack of communication between science and math teachers lead to segregation and ambiguities of concepts and language in students' mind. To remedy these problems educators suggest a variety of ways to integrate science and math. Some suggest that the best approach is teaching separate classes, others propose integrating math into the science course or integrating science into the math course or co-teaching math and science in the same class or a single teacher teaching both science and math in the same class.

Evaluation of Integrated Science and Math Content and/or Process on Student Achievement

Science and math "content" refers to what concepts, such as photosynthesis, students should know. Whereas "process" refers to how science and math is done. For example American Association for the Advancement of Science (AAAS, 1993) provides a list of science processes that includes observing, classifying, and hypothesizing.

As stated earlier, integration of math and science is basically linking science with math or vise versa. Generally, science is used in math typically as examples and math is used in science as a problem solving tool or to teach science concepts. As a result of this integrated teaching approach, students use the cross disciplinary approach to solve math problems or understand scientific patterns, but without actually understanding the concepts or logic of either disciplines. The integrated science and math teaching strategy is both challenging and demanding for both teachers and students. Douville, Pugalee, and Wallace (2003) studied the elementary teachers' perspective and their instructional practices related to integrated science, mathematics, and literacy. The qualitative analysis of the survey data in this study revealed that, although some teachers have a well developed process for integrating instruction, almost one fourth of the teachers did not identify any process for planning integrated instruction. The study suggests that the lack of conceptual connections among the three disciplines, science, math, and literacy, was related to the lack of a clear process for instructional planning. Conversely, Frykholm, and Glasson (2005) examined the integrated science and math content and pedagogical content knowledge of secondary science and math teachers using qualitative research. Their findings suggest that participating teachers increased their content knowledge as a result of professional development that integrated science and math.

Despite this growing body of literature that recommends integrating science and math, it is interesting that there is limited research that supports the notion that integration of science and math content and process has a positive impact on student achievement. Only a few studies have focused on measuring student achievement in math or science content. The Judson and Sawada (2000) study focused on a course where math was integrated into a science class. The study used science inquiry-oriented activities with data generating technologies to integrate math into one eighth-grade science class. The experimental group (science integrated with math) was compared with the control group (no integration). Based on the results from both groups, integration positively affected students' math achievement. The study reported statistically significant higher math scores, but there was no difference in science performance.

Childress (1996) conducted research on science and math process integration using the National Science Foundation supported integrated technology, science and math (TSM) curriculum. The study used quasi-experimental nonequivalent control group design with posttest as an instrument. There was no significant difference in achievement in use of technology between those who received integrated science, mathematics and technology instruction and those who did not. However, the treatment group did attempt to apply technology in their final project as a result of what they learned from the integrated science, math and technology lessons. The study did not report any difference in either math or science scores. Similarly, Merrill (2001) also used a quasi-experimental nonequivalent control group design with posttest as an instrument to investigate the impact of an integrated technology, math, and science [TMaSe] curricula to assess cognitive gain among students at the high school level. No significant cognitive gain among the experimental group was found. The study however, did not report on students' achievement in science, math or technology. Further, a recent study by Yasar, Little, Tuzun, Rajasethupathy, Maliekal, and Tahar (2006) examined the effect of Computational Math, Science and Technology (CMST) training to improve science and math education. After the training the district passing rate in the 8th grade math exam improved by 8% from 11% in 2003 to 19% in 2004 and remained at the same level in 2005.

In summary, one distinctive effort to improve science and math education is an approach that recognizes the similarities between science and math and seeks to appropriately and effectively integrate these two disciplines in teaching and learning (Berlin & White, 1992; NCTM, 2000; NRC, 1996). Integration of content in core disciplines is viewed as an important curricular component in promoting science and math literacy as it changes teachers' teaching practices. Teachers who have increased knowledge, skills and aptitude in both disciplines can teach integrated science and math content, which may ultimately improve students' learning and understanding of each discipline's content (NCTM, 2000; NRC, 1996).

CHAPTER III

METHODS

Participants

The present study utilized three cohorts of participant teachers. Cohort I consisted of ten participants among which nine were inservice teachers from six school districts. Of the nine inservice teachers six taught science, three taught math and one was a teacher aide who was in the process of obtaining science teaching certification. The participants varied in respect to certification level, but all nine of the classroom teachers were certified to teach in their teaching assignment for 2006-2007 (see Table 1).

Table 1. Cohort I Demographic Analysis: Type of Teaching Certificate(s) and Teaching Assignment(s)

Teacher Code Cohort-Year-Teacher number	Type of Certificate	Teaching Assignment
1-06-1	Grades 6 -12, Biology	Grades 9 -12 Chemistry
	Grades 6 -12, Chemistry	
	Grades 6 -12, Physical Science	
1-06-2	Grades 1-8, Elementary	Grade 6 Math
	Grades 1-8, Math	
1-06-3	Grades 4 - 8, Math / Science	Grade 8 Science
1-06-4	Grades 4 - 8, Science	Grades 6 and 7 Science

Table 1 (continued). Cohort I Demographic Analysis: Type of Teaching Certificate(s) and Teaching Assignment(s)

Teacher Code Cohort-Year-Teacher number	Type of Certificate	Teaching Assignment
1-06-5	Grades 6 -12, Biology	Grades 6 and 7 Math
	Grades 1-8, Elementary	
	Grades 6-12, Health Education	
1-06-6	EC - 4, Generalist	Grade 5 Science
	Grades 4 - 8, Generalist	
1-06-7	Grades 6 -12, Physical Education	Grade 6 Science
1-06-8	Grades 4-8, Science	Not teaching
1-06-9	Grades 1-8, Elementary	Grade 7 Math
	Grades 1- 8, Math	
1-06-10	None	Grades 6 -8 Science (Aide)

Cohort II consisted of 21 inservice teachers. Of the 21 teachers, representing nine school districts, all were certified to teach in their respective teaching assignments. Nine teachers taught science, eleven teachers taught math, and one of the teachers taught both math and science (see Table 2).

Table 2. Cohort II Demographic Analysis: Type of Teaching Certificate(s) and Teaching Assignment(s)

Teacher Code Cohort-Year-Teacher number	Type of Certificate	Teaching Assignment
2-07-1	Grade 4-8 Generalist	Grade 6-8 Math
	Grade 6-12 Business Education	
2-07-2	Grade 4-8 Science	Grade 5 Science
2-07-3	Special Education	Grade 6-8 Math

Table 2 (continued). Cohort II Demographic Analysis: Type of Teaching Certificate(s) and Teaching Assignment(s)

Teacher Code Cohort-Year-Teacher number	Type of Certificate	Teaching Assignment
2-07-4	Grade EC-4 Generalist	Grade 4-6 Math and Science
	Grade 4-8 Generalist	
2-07-5	Grade 4-8 Mathematics	Grade 7-9 Math
2-07-6	Grade 4-8 Generalist	Grade 8 Math
2-07-7	Grade 4-8 Mathematics	Grade 6 and 8 Math
2-07-8	Grade 4-8 Science	Grade 7 Science
2-07-9	Grade 1-8 General	Grade 6 Math
2-07-10	Grade EC-12 Special Education	Grade 4-6 Science
2-07-11	Elementary General	Grade 5 Science
	Elementary Speech	
2-07-12	Grade 1-6 Generalist	Grade 5 Science
2-07-13	Grade 4-8 Mathematics	Grade 7 Math
2-07-14	Grade 4-8 Generalist	Grade 5 Science
2-07-15	Grade K-12 Special Education	Grade 7-9 Math
	Grade EC-4 Generalist	
	Grade 4-8 Mathematics	
2-07-16	Special Education	Grade 8 Science
2-07-17	Grade 4-8 Mathematics	Grade 6-8 Math
2-07-18	Grade 4-8 Mathematics	Grade 4-6 Math
2-07-19	Grade 6-12 Composite Science	Grade 8 Science
2-07-20	Grade 1-8 Generalist	Grade 5 Math
2-07-21	EXCET	Grade 5 Science

Cohort III consisted of 17 teachers representing eight school districts. Seven teachers were teaching science, nine teachers were teaching math, and one teacher was certified in science, but was not teaching at the time of this professional development program. All the participants in Cohort III were certified to teach in their teaching assignments with the exception of one who was certified in special education (see Table 3).

Table 3. Cohort III Demographic Analysis: Type of Teaching Certificate(s) and Teaching Assignment(s)

Teacher Code Cohort-Year-Teacher number	Type of Certificate	Teaching Assignment
3-07-1	Grades 6 -12, Biology Grades 6 -12, Chemistry Grades 6 -12, Physical Science	Grades 9 -12 Chemistry
3-07-2	Grade 4-8 Generalist Grade 6-12 Business Education	Grade 6-8 Math
3-07-3	Grade 4-8 Science	Grade 5 Science
3-07-4	Special Education	Grade 6-8 Math
3-07-5	Grade 4-8 Mathematics	Grade 7-9 Math
3-07-6	Grade 4-8 Generalist	Grade 8 Math
3-07-7	Grade 4-8 Science	Grade 7 Science
3-07-8	Grade 1-8 General	Grade 6 Math
3-07-9	Grades 6 -12, Biology Grades 1-8, Elementary	Grades 6 and 7 Math
3-07-10	Grade 4-8 Generalist	Grade 5 Science
3-07-11	Grade K-12 Special Education Grade EC-4 Generalist Grade 4-8 Mathematics	Grade 7-9 Math

Table 3 (continued). Cohort III Demographic Analysis: Type of Teaching Certificate(s) and Teaching Assignment(s)

Teacher Code Cohort-Year-Teacher number	Type of Certificate	Teaching Assignment
3-07-12	Grade 4-8 Mathematics	Grade 6-8 Math
3-07-13	Grade 4-8 Generalist	Grade 7-9 Science
3-07-14	Grade 4-8 Mathematics	Grade 4-6 Math
3-07-15	Grades 6 -12, Physical Education	Grade 6 Science
3-07-16	Grades 4-8, Science	Not teaching
3-07-17	Grade 6-12 Composite Science	Grade 8 Science

Mixed Methods Design

Mixed methods research design contains elements of both quantitative and qualitative approaches. Quantitative research involves analysis of numerical data whereas qualitative research involves analysis of data such as words (interviews), pictures or objects. Using mixed methods enables data collection and analysis to be more accurate (Campbell & Fiske, 1959; Greene, 1997; Rocco, Bliss, Gallagher, & Perez-Prado, 2003; SenGupta, 1993; Webb, Campbell, Schwartz, & Sechrest, 1966). According to Greene (1997, p. 3), "Mixed methods have the potential of enabling us to understand more fully, to generate insights that are deeper and broader and to develop important claims that respect a wider range of interests and perspective." Additionally, Rocco, et al. (2003) suggests that the research design that is deemed the most appropriate should address the research questions in the study. Since the mixed methods design is a useful and therefore popular approach used in many evaluation studies, the present study utilized this research design. The study evaluated certain components of the Mix It Up: CSM professional development program (see the research questions).

Research Procedure

The main goal of the Correlated Science and Math model (CSM) training was to provide the inservice teachers an opportunity to experience linking science and math as recommended by the National Science Education Standards (NRC, 1996) and Principals and Standards for School Mathematics (NCTM, 2000) and to learn how to incorporate the CSM model into their classroom instructional practice. Different cohorts experienced different levels and versions of CSM instruction. The cohorts experienced intensive two week summer programs and academic year Saturday sessions. As a result of this Correlated Science and Math professional development program, it is predicted that both teachers and their students not only will see the important connections between disciplines, but also understand how one discipline can support learning of the other.

Cohort I.

The Cohort I training consisted of a two week-long summer (June 2006) session in correlated physics and math at Texas State University-San Marcos followed by six monthly Saturday sessions during the academic year sessions from September through May (2006 – 2007). The study collected data from both summer and academic year sessions. The inservice teachers were provided experiences that enabled them to strengthen their content knowledge in physics and math and experiences in correlating physics and math so that they could understand the connections between these two content areas. To further enhance their knowledge and repertoire, the participant teachers attended the academic year sessions during the school year where new correlated math and physics lessons were taught and discussions about implementing CSM lessons in the classroom were held. The course, Correlated Physics and Math (CPM) included physics concepts such as position, motion & speed, and accuracy & force and math concepts such as measurement and coordinate graphing.

Cohort II.

In the summer of 2007 two CSM sessions were offered. Cohort II attended the first summer session (June 3-15) that covered physics and math content. The physics was a replication of the CSM physics course, Correlated Physics and Math, from the summer of 2007 and included lessons on position, motion & speed, and accuracy & force and the correlated math concepts such as measurement, distance and coordinate graphing. Along with the physics course, the participants participated in a math-led CSM course, MTE 5311, Correlated Quantitative Reasoning and Science. The Correlated Quantitative Reasoning and Science course was redesigned to include the science topics that linked with the math. This course included science lessons on geologic time, the Metric-Saurus model, sequencing geologic events, percent composition, density inquiry, and the periodic table & properties of elements.

The participants were given a pretest in both the Correlated Physics and Math and the Correlated Quantitative Reasoning and Science courses prior to the beginning of the courses and they were given a posttest upon completion of the summer session.

Cohort III.

The second session (June 18 – 29), attended by Cohort III, consisted of a science-led Correlated Chemistry and Math (CCM) and a math-led CSM course, MTE 5315, Correlated Algebraic Reasoning and Science. The chemistry CSM course included topics on observed and measured physical properties, elements, and compounds & mixtures.

The math-led Correlated Algebraic Reasoning and Science course incorporated lessons on Earth motions, patterns, synthesis, and gas laws.

In addition to the summer sessions, academic year sessions were provided from September, 2007 through April, 2008 for both Cohort II and III. A summary of the correlated courses is depicted below in Table 4.

Table 4. Correlated Science and Math Courses: Cohort and Year

Semester	Cohort	Science
Summer 2006	Cohort I	Correlated Physics and Math
Fall 2006 Spring, 2007	Cohort I	Academic Year sessions
Summer 2007	Cohort II	Correlated Physics & Math and Correlated Quantitative Reasoning and Science
	Cohort III	Correlated Chemistry & Math and Correlated Algebraic Reasoning and Science
Fall 2007 Spring, 2008	Cohort II & Cohort III	Academic Year sessions

Research Design

Data Collection and Instruments.

The demographic data were obtained from all cohorts from review of teacher transcripts, teaching certificates and the teaching assignments. The transcripts were reviewed to determine the number of college course hours in math and each science content area. The results were used to analyze the content background of the teachers in the science disciplines that include physics, life science, chemistry, earth/space science as well as math.

To address the research questions framing this study, both qualitative and quantitative data were collected. To analyze the effects of the training on teachers' content knowledge, all cohorts were administered both science and math pre and posttests in each of the Correlated Science and Math (CSM) courses taught. With the exception of the physics test, the tests were multiple choice questions selected from released PRAXIS, TExES, and TAKS validated items. The physics test contained open-ended questions.

In the summer of 2006 one physics pretest and one posttest, each consisting of 42 questions, was given for the CPM course. In each course for the 2007 summer sessions, two pretests and two posttests, one for the science content and one for the math content were administered (see Table 5).

Table 5. Number of questions per Pretest and Posttest

Year, Course, Test	Pretest	Posttest
'06 Correlated Physics & Math		
Science	42	42
'07 Correlated Physics & Math		
Science	40	40
Math	31	30
'07 Correlated Quantitative Reasoning & Science		
Math	30	30
Science	27	27

Table 5 (continued). Number of questions per Pretest and Posttest

Year, Course, Test	Pretest	Posttest
'07 Correlated Chemistry & Math		
Science	40	30
Math	31	30
'07 Correlated Algebraic Reasoning & Science		
Math	30	30
Science	16	16

All of the pre and posttests were designed after the syllabus was constructed, but before the lessons were taught. The math concepts taught in the Correlated Physics and Math course related to the science concepts of position, motion & speed and accuracy & force. The math concepts taught were coordinate graphing, measurement, ratios, equations, and percent. The Correlated Chemistry and Math course covered the concepts of observations and measurement of physical properties, elements and compounds and mixtures. The math concepts connected with the chemistry content taught included measurement, ratios, equations, percent, circles, polygons, solids, symmetry, measuring angles, drawing a tangent, contact angle, length, area, volume, relating Fahrenheit and Celsius, scale factors, patterns, and circle graphs.

Math pre and posttests for the Correlated Quantitative Reasoning and Science course and the Correlated Algebraic Reasoning and Science courses assessed the math content covered in the courses. Additionally, science pre and posttest were administered to assess the amount of science knowledge gained as a result of the training in a math-led

CSM course. The science concepts included geologic time, density, periodic table of elements, and percent composition.

Additionally, during the summer sessions, participants reported in a journal their experiences during each day's lesson. To determine the degree to which teachers' understood Correlated Science and Math and to which they implemented Correlated Science and Math lessons in their classrooms, teacher homework, summer session evaluations, academic year sessions' evaluations, teacher lesson plans, and teacher classroom observations were analyzed.

Statistical Analysis.

To address the research questions framing this study, both qualitative and quantitative data were collected. Cohorts I, II & III teachers were administered pre and posttests on the correlated science and math content over the two years of the study (2006 -2007). The inservice teachers' science and math content knowledge were analyzed from these tests. A randomization test was used to analyze the pre and posttests. This test was chosen because of the possibility of violating the assumption of normality with a small sample size. A randomization test compares the test statistic of the sample to a randomly reordered set of data from the sample. Manly (1991, p. 15) concludes that within the same sample a more commonly used statistical analysis test, such as a *t* test, would give the same results. R software (R, 2006) was used for quantitative data analysis.

The test statistic (ts) value was calculated as the sum of the differences between the pre and posttest from the randomly reordered set of data. The pretests were expected to be lower than the posttest, which would result in a negative test statistic value. The smaller the test statistic value the greater the difference between the pretests and the posttests. The number of permutations conducted was determined by the number of paired tests (n). The permutations ranged from 1000 to 10000 depending on the number of paired data in the set. Those data sets where n = 7 were run with 1000 permutations and data sets where n is nine or greater were run with 10000 permutations. The reported data include the test statistic value (ts), the number of paired samples (n), and the *p* value (*p*). The alternative hypothesis for this study states that there is a difference between the scores of the pre and posttests. It is expected that the score of the pretest will be lower than the score of the posttest for each participant. This analysis determined if the content knowledge gained by the participants during this professional development program was significant.

For the qualitative analysis the researcher identified major themes and relationships. The question of whether the inservice teachers adopt the innovative strategies of CSM in their classroom instructional practices were measured via classroom observations (once per year), lesson plans (one per year), and discussions with the inservice teachers and the principal.

Validity

"Validity refers to how well an idea about reality really "fits" with actual reality" (Neuman, 2004, p. 112). "Validation is the process of compiling evidence that supports the interpretations and uses of the data and information collected using one or more of the instruments and procedures" (Sanders, 1994, p. 145). The study design must address issues of validity. Mixed methods act as a means for enhancing the validity of inference from a study (Campbell & Fiske, 1959; Webb, et al., 1966). For this reason, more and more evaluation studies are relying upon mixing quantitative and qualitative methods to both increase the validity of findings and also to enhance the overall scope of the study (SenGupta, 1993). In this present study, both external and internal validity will be addressed to assess the confounding variables.

Reliability

"Reliability means dependability or consistency" Neuman (2004, p. 112). "Reliability refers to the degree of consistency of the information obtained from an information gathering process" (Sanders, 1994, p. 153). Reliability of a study can be improved by using pretests, pilot studies and replication. The reliability of a research instrument generally means yielding the same results on repeated trials. Although unreliability is always present to a certain extent, a good quality instrument provides consistent results. For this study the reliability was improved by using three separate sessions over a two year period with five separate correlated science and math courses.

CHAPTER IV

RESULTS

Transcript Analysis

Cohort I.

Ten teacher transcripts were analyzed. Table 6 lists each participant's credit hours in both science and math content courses as well as either a science or math methods course. Most of Cohort I participants are post-baccalaureate certified teachers who have undergraduate degrees in a discipline other than science. One participant was a teacher aide working toward certification. Two participants had an undergraduate degree in biology and one participant had an undergraduate degree in chemistry. One of the participants was a high school chemistry teacher; therefore, those college course hours were excluded from analysis, because the professional development program, specifically, focused on middle school teachers. The mean number of college course science hours is 4.26 ranging from 4-58. The mean number of college course math hours is 6.25 ranging from 0-21 hours for this cohort (see Table 7).

Table 6. Cohort I Transcript Analysis: number of college course semester hours

Teacher code: Cohort-Year-Teacher number	Math	Physics	Chemistry	Earth	Space	Biology	Science Methods	Math Methods
1-06-1	9	11	30	3	-	80	-	0
1-06-2	8	-	-	-	-	4	-	-

Table 6 (continued). Cohort I Transcript Analysis: number of college course semester hours

Teacher code: Cohort-Year-Teacher number	Math	Physics	Chemistry	Earth	Space	Biology	Science Methods	Math Methods
1-06-3	21	7	4	12	6	8	7	-
1-06-4	3	-	-	-	-	10	4	3
1-06-5	3	3	6	-	-	34	-	-
1-06-6	3	-	-	-	-	14	-	-
1-06-7	3	-	-	-	-	15	-	-
1-06-8	-	3	8	16	-	31	3	3
1-06-9	9	-	-	3	-	5	-	-
1-06-10	9	4	51	-	-	32	-	-

Table 7. Cohort I Summary of Transcript Analysis: number of college course semester hours excluding outliers

	Math	Science	Science and Math Methods
Mean	6.25	4.26	1.25
Median	3.00	0.00	0.00
Range	0-21	4-58	0-7

Cohort II.

The 21 participants in Cohort II were post-baccalaureate certified teachers with degrees in fields other than science or math. An analysis was made of the 16 transcripts received from the participants. From an analysis of these transcripts, the mean number of college course science hours is 2.04 ranging from 0-16 hours. The mean number of college course math hours is 5.76 ranging from 0-15 (see Table 8 and Table 9).

Table 8. Cohort II Transcript Analysis: number of college course semester hour

Teacher code: Cohort-Year-Teacher number	Math	Physics	Chemistry	Earth	Space	Biology	Science Methods	Math Methods
2-07-1	15	-	-	-	-	-	-	-
2-07-2	-	-	-	-	-	-	-	-
2-07-3	3	-	-	-	-	12	-	-
2-07-4	-	-	-	-	-	-	-	-
2-07-5	6	16	-	-	-	-	-	-
2-07-6	6	-	3	-	-	-	-	-
2-07-7	12	-	-	-	-	6	-	-
2-07-8	-	-	-	-	-	-	-	-
2-07-9	12	3	3	-	-	4	-	-
2-07-10	3	-	-	5	-	3	-	-
2-07-11	-	-	-	-	-	8	-	-
2-07-12	6	-	-	-	-	4	-	-
2-07-13	15	12	-	-	-	-	-	-
2-07-14	6	3	-	-	-	8	-	-
2-07-15	-	-	6	-	-	-	-	-
2-07-16	-	-	8	-	-	14	-	-
2-07-17	-	-	-	-	-	-	-	-
2-07-18	12	12	-	-	-	-	-	-
2-07-19	3	4	8	-	-	12	-	-
2-07-20	6	-	-	3	-	-	-	-
2-07-21	-	-	-	3	-	8	-	-

Table 9. Cohort II Summary of Transcript Analysis: number of college course semester hours

	Math	Science	Science and Math Methods
Mean	5.76	2.04	0.00
Median	6.00	0.00	0.00
Range	0-15	0-16	0-0

Cohort III.

Thirteen of the 17 teachers in this cohort returned transcripts. Two of the teachers had baccalaureate degrees in biology and one in chemistry. The data from two participants were excluded because one taught high school chemistry and one had a degree in chemistry. One participant was a teacher aide working toward teacher certification. The other teachers had baccalaureate degrees in content areas other than science or math and post baccalaureate teacher certification. The analysis of these transcripts excluding the data from the high school teacher and the teacher with a chemistry degree revealed the mean number of college course science hours was 2.92 ranging from 0-58 hours. The mean number of college course math hours was 5.90 ranging from 0-15 (see to Table 10 and Table 11).

Table 10. Cohort III Transcript Analysis: number of college course semester hours

Teacher Code: Cohort-Year-Teacher number	Math	Physics	Chemistry	Earth	Space	Biology	Science Methods	Math Methos
3-07-1	9	11	30	3	-	80	-	3
3-07-2	15	-	-	-	-	-	-	-

Table 10 (continued). Cohort III Transcript Analysis: number of college course semester hours

Teacher Code: Cohort-Year-Teacher number	Math	Physics	Chemistry	Earth	Space	Biology	Science Methods	Math Methods
3-07-3	-	-	-	-	-	-	-	-
3-07-4	3	-	-	-	-	12	-	-
3-07-5	6	16	-	-	-	-	-	-
3-07-6	6	-	3	-	-	-	-	-
3-07-7	-	-	-	-	-	-	-	-
3-07-8	8	-	-	-	-	4	-	-
3-07-9	3	3	6	-	-	34	-	-
3-07-10	3	-	-	-	-	14	-	-
3-07-11	-	-	6	-	-	-	-	-
3-07-12	-	-	-	-	-	-	-	-
3-07-13	-	-	-	-	-	-	-	-
3-07-14	12	12	-	-	-	-	-	-
3-07-15	-	3	8	16	-	31	3	3
3-07-16	9	4	51	-	-	32	-	-
3-07-17	3	4	8	-	-	12	-	-

Table 11. Cohort III Summary of Transcript Analysis: number of college course semester hours excluding outliers

	Math	Science	Science and Math Methods
Mean	5.90	2.92	0.60
Median	6.00	0.00	0.00
Range	0-15	0-58	0-3

In addition to the content course hours in a particular subject, the transcripts revealed that 15 out of the 28 total participants in Cohort II and III gained teacher certification through an alternative or emergency certification process. The data for certification process is unknown for Cohort I.

Science and Math Teachers' Content Knowledge

Cohort I.

Assessing gains in conceptual understanding of both science and math content knowledge of inservice teachers was a primary objective of this research. In 2006, pre and posttests for Correlated Physics and Math course were administered to all ten inservice teachers and all scores were used for data analysis. A randomization test was conducted on the scores for all participants and separately for the science teachers. There were only three math teachers which was not a sufficient number of scores for data analysis (see Table 12).

Table 12. Cohort I Statistical Analysis of Randomization test

Test	ts	n	*p*
Correlated Physics & Math			
physics tests			
all participants	-275	10	.0004**
science teachers	-168	7	.007**

$^{*}p<.05$. $^{**}p<.01$. $^{***}p<.001$.

Cohort II.

There were 16 out of the 21 participants who completed both the physics pre and posttests in the Correlated Physics and Math course. Four participants did not take the posttest and one participant did not take either the pre or posttest. The scores were separated into science and math teachers to determine if there was a difference in the content learned between science and math teachers. In this group, there were seven science teachers and nine math teachers. In the Correlated Physics and Math course, the participants were given math content pre and posttests Eighteen of the 21 participants took the math content pre and posttests; 8 science teachers and 10 math teachers. One participant missed the posttest and two participants missed both the pre and post tests.

This cohort, concurrently, took a Correlated Quantitative Math and Science course. The math content pre and posttests for this course were given to 20 out of 21 participants with one teacher who did not take the post test. Those scores were excluded. The scores for the nine science and 11 math teachers were separated for analysis. Science content pre and posttests were given to 20 of the 21 teachers with the same number of science and math teacher scores analyzed separately (see Table 13).

Table 13. Cohort II Statistical Analysis of Randomization test

Name of Test	ts	n	*p*
Correlated Physics and Math			
physics tests			
all participants	-286.5	16	.0051
science teachers	-125.5	7	.068
math teachers	-161	9	.0261*
Correlated Physics and Math			
math content tests			
all participants	-16	18	.44
science teachers	-92	8	.0184*
math teachers	76	10	.8239

Table 13 (continued). Cohort II Statistical Analysis of Randomization test

Name of Test	ts	n	*p*
Correlated Quantitative Reasoning and Science			
math content tests			
all participants	-122	20	.0749
science teachers	-74	9	.036*
math teachers	-48	11	.3073
Correlated Quantitative Reasoning and Science			
science content tests			
all participants	-935	10	< .0001***
science teachers	-375	9	< .0001***
math teachers	-560	11	< .0001***

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

Cohort III.

This cohort took a Correlated Chemistry and Math course concurrently with a Correlated Algebraic Reasoning and Science course. There were 16 of 17 participants who took both chemistry pre and posttests. The scores for the pre and posttests of the participant who did not take the post test were excluded. The scores were split into science and math teacher scores for analysis. The math content pre and post tests were treated the same way by analyzing the scores for 14 of 17 participants and seven science teacher scores and seven math teacher scores. Those scores for participants who did not take one or both of the pre and posttest were excluded.

All 17 participants in the Correlated Algebraic Reasoning and Science course took both the math content pre and posttests. There were 15 participants who took the science content tests and two missed the posttests. Their scores were excluded from analysis. Each of these tests was further separated to be analyzed for differences between the scores of the science teachers and the math teachers. Nine science teachers and 11 math teachers took both the math content and science content tests (see Table 14).

Table 14. Cohort III Analysis of Randomization test

Test	ts	n	*p*
Correlated Chemistry and Math			
Chemistry tests			
all participants	-209	16	.0028**
science teachers	-69	7	.045*
math teachers	-140	9	.0149*
Correlated Chemistry and Math			
Math content test			
all participants	-29	14	.325
science teachers	-15	7	.242
math teachers	-14	7	.417
Correlated Algebraic Reasoning and Science			
Math content tests			
all participants	-476	17	0***
science teachers	-254	8	.0021**
math teachers	-222	9	.0026**
Correlated Algebraic Reasoning and Science			
Science content tests			
all participants	-117	15	.1197
science teachers	-49	7	.224
math teachers	-68	8	.1721

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

Other data sources such as teacher homework, reflections, questionnaires, summer session evaluation, and academic year session evaluations suggest that the Correlated Science and Math (CSM) instruction was highly effective in confronting participants with the limitation of their own conceptual understanding of the content material in both science and math. The analysis of their reflections on their own learning indicates that participants developed new understanding of essential terms in both physics and math, visualized essential concepts, and gained understanding of similar concepts used in science (physics & chemistry) and math.

Improvement Instructional Skills

To assess the instructional skills of the inservice teachers, the data sources used were teacher lesson plans, teacher homework and teacher classroom observations. The analysis of these data sources provided evidence of improved understanding of the targeted science and math concepts and processes. However, observations of their classrooms revealed a lack of knowledge about fundamental concepts that were not taught in Correlated Science and Math (CSM), such as density and how to measure the volume of irregular shaped objects. These misconceptions or lack of knowledge were gently addressed during monthly training sessions by people other than project directors who observed the lessons when the teachers presented the lesson observed in their classrooms.

Through journal entries, lesson plans, reflections, questionnaires, observations and course evaluation several themes appeared. Teachers felt uncomfortable teaching a content area other than their own. Fifty percent of the teachers in the summer 2007 sessions identified content knowledge as a major obstacle to correlating lessons as reflected in the following two statements by teachers. "I had a hard time seeing the connections between inequalities and energy." "The physics and math are at times so high level that I feel that I can't make a connection – the gap is too great."

Teachers recognize the effectiveness of correlating science and math content and using the proper language. One participant stated "The math naturally correlates with the science and while I am already doing the math I am not teaching it using the same terminology as the math teachers." "Vocabulary makes a big difference. Both science/math need to correlate." Content knowledge did not necessarily transfer to the classroom. During classroom observations incorrect math terms were used and content was presented superficially rather than in depth.

Difficulties in teaming were a hindrance for teachers in correlating science and math in the classroom. Eighty-three percent of the teachers from the summer 2007 sessions expressed frustration with not having a common planning period with their team member and in not having sufficient planning time. Lack of time to plan lessons in the summer presented a problem with Cohort I, when planning their lessons. Cohort I commented they needed more time to plan a CSM lesson that requires a different skill set. The lessons taught by Cohort I provided students with new ideas and awareness of how science and math can be brought together in a lesson. Interviews with the teachers revealed in some cases that the logistics of scheduling within the school around the many different courses and extracurricular activities that teachers coach was the real culprit in being able to meet with their team teacher.

Several themes appeared. Teachers' demonstrated a better understanding of what correlated science and math is and ways in which to implement CSM lessons in the classroom. "I never thought of speed as a fraction.", "I liked the correlated lesson part. It gave an idea on how to teach math using science concept. It made math interesting.", and "I liked seeing the math science connection" were comments teachers made that reflected a new understanding of CSM. Learning how to work with a team member was important to success in developing a CSM lesson. One teacher commented that they "learned many fantastic approaches to correlating my mathematics lesson with the science teacher on my team." She was also pleased with the idea of keeping her students engaged in both mathematics and science. Another teacher would seek support from their math team and found students were more successful in learning the science concepts if she used the same language and formulas the math teacher did.

Following 2006 summer session, six of the seven participants were observed in the classroom and four classroom observations were made following the 2007 summer sessions. Correlated lessons were observed being taught during the 2006-2007 academic year. There were no correlated lessons taught during the scheduled classroom observation during the 2007-2008 academic year. However, unlike Cohort I, participants in Cohort II and III were not required to teach a correlated lesson during the observation. During the interviews with the teachers they reflected on lack of time to prepare CSM lessons, the necessity to concentrate teaching on the Texas Assessment of Knowledge and Skills (TAKS) objectives, and the lack of manipulatives in the classroom. They did emphasize they gained a better understanding of math and science concepts through the program and did use more integration of science and math concepts in their classroom along with the proper content language.

Interviews with the principal indicated that they were not aware of the teachers' participation in the MIX program. One principal was very aware and supportive of her teachers. She noted that after the summer session, the teacher's classroom appeared "different." The teacher had changed the way she had decorated her room.

Improvement in Student Learning – TAKS

Texas Assessment of Knowledge and Skills (TAKS) is the state's assessment of student knowledge. The goal of any professional development program is to improve student learning. One measure of student learning is through TAKS scores. Of the 28 teachers teaching from all three cohorts, 12 teachers returned TAKS scores for their students. Of those, one teacher submitted scores for 3 consecutive years and one teacher submitted scores for two consecutive years (see Table 15).

Table 15. Student TAKS scores

	2006		2007		2008	
Subject	% Met	% Commended	% Met	% Commended	% Met	% Commended
Math	-	-	-	-	82	18
Math	-	-	-	-	-	-
Math	-	-	70	29	-	-
Science	-	-	58	2	62.6	6
Science	-	-	40	3	-	-
Science	-	-	-	-	68	18
Science	-	-	91	19	-	-
Science	-	-	84	36	-	-
Science	-	-	-	-	87.8	42.4
Science	51	0	67	17	44	3.3
Science	-	-	78	22	-	-

Table 15 (continued). Student TAKS scores

	2006		2007		2008	
Subject	% Met	% Commended	% Met	% Commended	% Met	% Commended
Science	-	-	49	5	-	-
Science	-	-	89	16	-	-

In order to determine if there was a gain in student learning due to teacher participation in this professional development program, student TAKS scores would need to be evaluated to identify any trends. There was no data for this due to the few student TAKS scores submitted by the teachers.

To meet the goals of this professional development program, a program would need to include rigorous lessons in content and teaching strategies to assist teachers in implementing CSM lessons. The design of this program was aimed at meeting its goals, which are to increase teacher knowledge in science and math and to teach strategies for executing CSM in the classroom. With increase teacher content knowledge and CSM lessons taught in the classroom, student learning should increase. The evaluation process took into consideration where the content level of the teacher was at the beginning of the program with transcripts and pretests and at the end of the program with posttests to assess gains in content knowledge made by the teachers. These measures along with classroom observations and feedback from the teachers revealed the teachers' gain in content knowledge, their appreciation for the effectiveness of the CSM model in student learning and how much they use correlated lessons in their teaching.

CHAPTER V

DISCUSSION

The Correlated Science and Math (CSM) instructional model requires that the teacher have a thorough understanding of the science and math content and the pedagogy necessary to correlate science and math concepts using the proper language of the discipline. A primary goal of this professional development program was to increase the participants' science and math content knowledge and secondly, provide the skills needed to implement teaching science and math conceptually by using research identified best teaching strategies, called Best Practice. Best practice is defined as "A practice … or technique or methodology that, through experience and research, has reliably led to a desired or optimum result" (best practice, Webster's New Millennium Dictionary) Ultimately, an increase in student learning would be reflected in improved scores on the Texas Assessment of Knowledge and Skills (TAKS).

Transcript Analysis

A teacher can be only as effective as the depth of their content knowledge. Science and math concepts are taught conceptually to students in the Correlated Science and Math model (CSM); therefore, it is necessary for the teacher to have a thorough understanding of both science and math. Without a deep understanding of the content knowledge teachers have a difficult time teaching common concepts when integrating science and math (Pang & Good, 2000). Lewis and Jeanpierre (2006) found that teachers who had participated in a program to increase their content knowledge in science and math were more confident in teaching science and math and tended to teach more integrated science and math. A major goal of this professional development program was to increase the content knowledge in physics and chemistry and in areas of quantitative and algebraic reasoning for all three cohorts.

The transcript analysis revealed that the science and math teachers who participated in this study had few college course hours in science or math to support strong science or math content knowledge. Texas State University-San Marcos requires a minimum number of 21 hours for a minor in Biology, Math -17 hours, Chemistry -23 hours, Physics-21 hours and Geology-19 hours (p 59-60, Texas State University Catalogue 2008-2010). One participant in Cohort I, and three each from Cohort II and III, met the minimum requirements for a minor in math at Texas State University. Although three of the teachers had science degrees, none taught in that content area. The high school teacher who had a biology degree was teaching chemistry. However, she had 30 hours of chemistry. The middle school teacher who had a biology degree teaches math and has only three hours of math. The third teacher with a science degree has a chemistry degree from a foreign country, but is an aide in middle school and is not a certified teacher with her own classroom. With the exception of the three teachers with science degrees, only four participants from the 28 participants within all cohorts would meet the minimum requirements for a minor in Biology and none would meet the minimum requirements for a minor in the other science fields.

Alternative certification is an option to gain teaching certification in order to move teachers in to the classroom more rapidly. More than one-half of the new Texas teachers are certified through Alternative Certification Programs operated by businesses, Educational Service Centers, community colleges and universities (National Center for Alternative Certification, 2004; How do I apply for certification, State Board of Education, 2008). The Alternative Certification Programs that are not university-based are not held to the same high standards as are universities. There is no minimum GPA or number of coursework required as university-based programs. Alternative Certification Programs lack the requirement for field-based experience and content pedagogy. The requirements set out by the Texas State Board of Education for someone with a Bachelors degree seeking to teach may receive alternative certification through programs that "can be completed in a year, during which time …a paid teaching position in a public classroom" can be held (How to become a teacher in Texas, State Board of Education, 2008). The result is that teachers certified by some Alternative Certification Programs may not adequately be prepared to enter the classroom. This was demonstrated in this study in the number of participants that are alternatively certified (15 out of 28) and with the minimum college content course hours that the participants have in their teaching field.

Science and Math Teachers' Content Knowledge

This professional development program was designed to increase participants' content knowledge by teaching more in depth science and math content through correlated lessons, inquiry and best practice teaching strategies. The content knowledge gained by the teachers through this professional program was measured with pre and posttests for each of the Correlated Science and Math (CSM) courses. The scores were analyzed for each cohort as a group, and the scores were further divided into those of science teachers and those of math teachers. It would be expected in this study that the math teachers would come into the program with a more conceptual understanding of math that would be reflected in higher pre and post test scores. Therefore, the difference in scores on the pre and posttests would not show a significant gain for the math content tests for each CSM course. Likewise, it would be predicted that the science teachers' scores on the pre and posttests for the science content tests would be greater for science teachers than for the math teachers due to a more conceptual understanding of science. Therefore, there would not be a significant difference in the science content tests for the science teachers.

The cohorts, as individual groups, showed significant gains in physics content for both of the Correlated Physics and Math courses, the science content for Correlated Quantitative Reasoning and Science, chemistry content in the Correlated Chemistry and Math course, and the math content for Correlated Algebraic Reasoning and Science course (see Tables 12, 13, and 14). When participants' scores are analyzed as a cohort, more significant gains are shown in the area of science than in the area of math.

Science teachers showed significant gains in content knowledge in six out of nine pre/posttests given. These include the physics content of the '06 Correlated Physics and Math course, science and math content of the Correlated Quantitative Reasoning and Science course, the chemistry content of the Correlated Chemistry and Math course, and the math content of the Correlated Algebraic Reasoning and Science course (see Tables 12, 13, and 14).

The math teachers showed significant gains in four out of eight content tests given. There were three math teachers in Cohort I and, therefore, no statistical analysis was conducted for the physics content of the '06 Correlated Physics and Math course. The math teachers showed significant gains in content knowledge in the physics content of the '07 CPM course, science content of Correlated Quantitative Reasoning and Science course, chemistry content of Correlated Chemistry and Math course, and the math content of the Correlated Algebraic Reasoning and Science course (see Tables 12, 13 and 14).

Overall there were significant gains in five math content pre and posttests and nine science content pre and posttests. Participants in the '06 Correlated Physics and Math course, Cohort I, showed significant gains in physics content as a whole group and the science teachers as a separate group. Cohort II took a Correlated Physics and Math course concurrently with Correlated Quantitative Reasoning and Science course. As a group they showed significant gains in the physics content of the Correlated Physics and Math course and the science content of the Correlated Quantitative Reasoning and Science course. They did not show significant gains in the math content areas for either course. The science teachers showed gains in the science and math content tests for both courses. The math teachers showed significant gains in the science content for both courses, but not in the math content for either course. An anomaly for the scores in the math content tests for Correlated Physics and Math course was the higher mean average on the pretest than the posttest of the math teachers. Cohort III participated in the Correlated Chemistry and Math course concurrently with Correlated Algebraic Reasoning and Science course. The group as a whole and separately as science and math teachers gained significantly in the science content area of the chemistry-led course and showed no significant gains in the math content of the chemistry-led course. Similar results were noted in the math-led Correlated Algebraic Reasoning and Science course. The group as a whole and the science and math teachers separately showed significant gains in the math content of the math-led course and not significant gains in the science content of the math-led course.

The significant differences in the pre and posttests could be due to several factors such as the teachers' prior content knowledge, the content material selected for the course, different instructors for each course and the rigor of the tests. The significant increase in science content knowledge by both science and math teachers may be due to the teachers' low prior content knowledge of the material presented in these courses. The mean scores on the math content pretests for the Correlated Quantitative Reasoning and Science course were in general much higher than the scores on the science content pretests in the math course. This suggests that the participants had a better background in this math content area than in the science content presented in the math course. It might also suggest that the content in the math pre and posttest was low. Cohort III had higher science content pretests mean scores in Correlated Algebraic Reasoning and Science course than math content pretest scores suggesting the teachers had a stronger basis in the general science content presented in this course than in the math content presented in this course. It might also suggest that the level of the pre and post test science content was low. Stronger prior content knowledge of the material presented in the course could explain the differences in the significant gains in the math courses. A prior strong working knowledge of the math content presented in the chemistry course could explain why the participants did not make significant gains in the math content of the chemistry-led Correlated Chemistry and Math course. This is reflected in a narrow difference in the mean pre and post test scores. This may also reflect the chemistry and math content material chosen for the Correlated Chemistry and Math course. In the physics-led Correlated Physics and Math course, Cohort II, the science teachers showed gains in the math content and the math teachers showed gains in the science content. The content knowledge the teachers brought to the professional development and the specific material presented may reflect the different areas where significant gains in content knowledge were made and the content areas where significant gains were not made.

The teachers had a greater gain in the science content areas than in the math content areas over all the courses. This is contrary to a study with students who were taught in an integrated science and math course. Students participating in this study of an integrated math and science class had a significant increase in the math content learned, but not the science content (Judson & Sawada, 2000). It may be that the abstract nature of math is more difficult for students to comprehend than for adults or it may be due to the level of rigor of the test.

Improvement of Instructional Skills

Overall, the teachers reported a better understanding of what correlated science and math lessons are and the awareness using correlation in the classroom. However, they did not actually increase their use of Correlated Science and Math (CSM) lessons, as reported in journals, course evaluation and observations. On the other hand, classroom observations of their lessons provided evidence that the teachers were able to teach integrated, if not correlated science and math lessons.

Several barriers impact the ability to implement CSM lessons. Many of the teachers commented that they had difficulty in moving toward using more correlated science and math in their classes. Teachers continued to feel inadequate with their content knowledge of the subject in which they are not certified. Support from their team member could alleviate some of this concern, however, the teams members must be able to work together effectively. These cohorts identified problematic areas for integration of science and math that are similar to those previously identified by Huntley (1998). These include planning time, joint planning periods with team member, lack of materials, lack of administrative support and the pressure to teach TAKS objectives. Despite, the barriers to using correlated lessons, the teachers continue to express a positive attitude toward the need to teach science and math conceptually using the appropriate language and their commitment to continue to move in that direction.

Improvement in Student Learning – TAKS

The ultimate goal of teacher professional development and education reform is to have a positive effect on students' understanding of science and math concepts. The only valid measure of impact on student achievement as a result of professional development is to conduct a longitudinal study on individual students. However, this is not currently possible. The Texas Education Agency (TEA) analyzes trends in TAKS scores (TEA, 2008). Evaluating the trends in students' TAKS performance for each teacher would be appropriate for this study. However, no trends are possible to discern, because few teachers submitted TAKS scores for consecutive years.

Conclusion

This two year professional development program was the first training project that provided intense instruction in content knowledge utilizing correlated science and math courses and lessons. The correlated courses were designed to increase teacher content knowledge and improve teacher instructional skills with the expectation that teachers would teach more correlated science and math lessons in their classrooms. In turn, this was predicted to improve student performance. It takes time to implement new teaching strategies in order to let go of less effective strategies and learn how to successfully implement the new teaching strategies (Crandall, Eisemann, & Louis, 1986). Professional development must be extensive and teachers given enough time to learn new teaching skills (Supovitz & Turner, 2000). The teachers also must let go of previous teaching methods to be able to implement the newly learned teaching strategies (Crandall, Eisemann, & Louis, 1986). It was not expected from this study that these teachers would be able to immediately transfer the acquired knowledge of Correlated Science and Math (CSM) lessons to the classroom. However, they did show a greater awareness of CSM and began to slowly increase integration of science and math in their lessons. To fully see the effects of this professional development program, these teachers should be followed through the course of several years.

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