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AN EVALUATION OF A PROFESSIONAL DEVELOPMENT PROGRAM
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Dedication

This dissertation is dedicated to my mother, Sue Barber, who tirelessly helped me by proofreading my papers, and giving me the support I needed throughout the entire process. Next, to my late father, John Barber, who encouraged me to begin the program, and I am sorry cannot see me at the end. Also, to my husband and youngest son who all went without my attention for many, many weekends as I worked or attended classes. Next, to my colleagues who all went above and beyond to ensure the Interlocal moved forward with and without me. Lastly, to my mentors and friends, Joyce Jech and Melvina Prather, who devoted years of service to public education, and inspired and encouraged me throughout my educational career. I include in this dedication all of my former students; it was each of you who gave me the inspiration to be a life-long learner.

Table of Contents

List of Tables

List of Figures

Abstract

This program evaluation sought to determine the effectiveness of a mathematics professional development program. The population for this study included 61 teachers, all who taught elementary math to regular, special education or alternative school students. The researcher provided descriptive statistics using graphs and quotes from teacher participants to answer three questions related to the desired teacher participant outcomes: Did teacher participants increase their mathematics instruction efficacy? Did teacher participants improve their instructional preparedness to teach mathematics content? Did the mathematics content knowledge of teacher participants increase?

Program evaluation was determined by analyzing the relationships of the teacher participants to various proposed outcomes, including teacher efficacy, mathematics pedagogy, and content knowledge. It also reviews theories related to adult learning and self-efficacy, as well as social cognitive learning.

Chapter 1: Introduction

In the past two decades, considerable external pressure has been placed on school systems to improve student achievement by improving teacher quality. With the passage of the No Child Left Behind (NCLB) law, high stakes standardized tests became the primary metric to measure teacher and school performance. In the current age of accountability, where federal, state and local authorities govern education, improving teacher quality is an essential component of any strategy to create high-performing schools. Professional development for teachers, also known as continuing education, staff development, in-service training, and workshops, is viewed by policy makers, school administrators, and the public as a means to improve instructional practice and a vital tool for instituting school-wide change (Ball & Cohen, 1999; Darling-Hammond, 2004; Guskey, 2003; Newman, King, & Youngs, 2000). Yet according to Desimone (2002), most teachers participate in only the minimal professional learning required by the state or district each year, despite the potential benefit to improving teaching and enhancing student learning.

While it is understood that teachers are key to improvement in student learning, and there are demands led by educational scholars and policy makers to provide high quality professional development to teachers, there is little guidance on what constitutes ‘high quality’ professional development that would enhance teacher content knowledge or improve instructional practices. Furthermore, little empirical evidence exists to guide administrators in providing professional development that improves teacher self-efficacy and leads to positive change in teacher knowledge, skills, and performance in the classroom. Many of the professional development programs have taken on a one size fits all approach and do not acknowledge that teachers have unique learning needs that must be met if programs are to be successful (Desimone, Porter, Garet, Yoon, & Birman, 2002; Corcoran, McVay, & Riordan, 2003; Garet, Porter, Desimone, Birman, & Yoon, 2001). Despite considerable evidence that the traditional professional development activities were insufficient in improving instruction, teachers in a national survey reported that one-shot, in-service trainings were the dominant activities used for their growth (Barber, & Mourshed, 2007; Borko, 2004; Darling-Hammond, Chung Wei, Richardson, & Orphanos, 2009; Lumpe, 2007).

Professional development has traditionally involved outside experts who present on topics deemed by school administrators as suitable for teachers. In such an approach, there are rarely follow-up discussions or activities following the initial presentation. Considerable evidence calls into question the effectiveness of traditional professional development (Birman, Porter, & Garet, 2000; Hofmeister, 2004). Loucks-Horsley, Hewson, Love, and Stiles (1998) state that commonly used formats for teacher-training activities do not promote the kind of change in instructional practice that would enhance academic achievement. The lack of significance is troubling because teacher learning and growth are a means of developing quality teachers and promoting better evaluation outcomes (Borko, 2004; Desimone, Smith, Hayes, & Frisvold, 2005; Desimone, Smith, & Frisvold, 2007; Smith, Desimone, & Ueno, 2005). In fact, it is hard to imagine that any professional work effectively adapts to changing circumstances without quality learning opportunities (Guskey, 1986). Each year school districts and the federal government spend millions of dollars on forms of professional development. More emphasis has been devoted to planning, implementation and possibly the follow-up than on evaluating outcomes of professional development expenditures (Guskey, 2000).

Problem Statement

In mathematics education, there are expectations for teachers to teach new, more challenging mathematics to a very diverse audience using active learning approaches designed to develop understanding; however, according to Ball, Hill, and Bass, (2005), the quality of mathematics teaching depends on teachers' knowledge of the content and many teachers lack sound mathematical understanding and skill. This is no surprise because "most teachers are graduates of the very system that we seek to improve" (Ball, Hill, & Bass, 2005, p. 14). Blame is placed on mathematics training opportunities. Studies over the past 15 years consistently reveal that the mathematical knowledge of many teachers is dismayingly thin (Ball, Hill, & Bass, 2005). This is true for many who teach in schools included in this study. Many of these elementary teachers did not go into teaching because they wanted to teach math, and these same teachers cannot comfortably answer questions such as: Why does it work to add zero on the right when multiplying by 10, or two zeros when multiplying by 100? What is the probability that in a class of 30 students, two people will share a birthday? Why, when the number includes a decimal, do we move the decimal point over instead of adding zeros?

Professional development's unproven history of effectiveness, and the lack of strong evidence showing its direct link to improvements in teacher performance or student learning, have led school leaders and other stakeholders to demand that professional development activities show evidence that they can shape positive mindsets, enhance motivation, build knowledge, and improve practice (Corcoran, 1995; Newmann, King, & Youngs, 2000). Rigorous program evaluation is necessary following professional development training to determine whether or not the teachers did improve their math content knowledge and quality of instruction (Guskey, 2003). Considerable resources were invested into the professional training program at the center of this evaluation, but to date, no systematic study of the program has been conducted. Without evidence on the program's implementation and effectiveness, administrators responsible for serving the professional needs of educators to improve their math instruction must rely on speculation and conjecture as the sources of knowledge for future program design and development. Speculation and assumptions are prone to decisional and attribution errors that can affect the effectiveness and efficiency of future work.

A systemic evaluation of the mathematics professional development program is needed to establish objective evidence so that program administrators can (1) determine if intended program outcomes were observed, and (2) to explain why and how features of the program produced observed outcomes. Without any existing evidence, this evaluation study addresses a knowledge-gap that affects the decisions and actions of local actors. The evidence, although limited to one program that was delivered in a specific context, has implications for the larger professional development conversation.

Purpose of Study

The purpose of this study was to evaluate a mathematics professional development program to determine if the outcomes of increased efficacy for math instruction, instructional preparedness, and increased math content knowledge were observed. This study involved elementary teachers and spanned a three-year time period. The design used by the researcher to evaluate the program included an analysis taken from the results of pre-post instruments to measure teacher efficacy, instructional preparedness to teach math, and teacher mathematics content knowledge. The two individual projects that made up this mathematics professional development program each had a ten-day summer institute with four follow-up training sessions. The training was held at a facility in Hominy, Oklahoma with some teacher participants traveling daily as much as 300 miles round-trip. Each Friday of the institute, the participants would go off-site to various locations for specific on-sight application learning. The program was led by higher-education mathematics professors, with additional business partners to demonstrate real-world applications and technology integration. The Oklahoma State Department of Education funded this program through a discretionary grant at a total cost of $298,000. The study used a mix-method approach to answer the following questions:

(1) Did teacher participants increase their efficacy for mathematics instruction?

(2) Did teacher participants improve their instructional preparedness to teach mathematics content?

(3) Did the mathematics content knowledge of teacher participants increase?

The research focus for this evaluation was chosen because the researcher felt that results would reveal an overwhelming focus on teacher knowledge and beliefs.

Outline of the Dissertation

In the next chapter the literature on professional development, especially the characteristics of effective activities, was reviewed. Also reviewed were theories related to self-efficacy and adult learning, and how teacher knowledge and pedagogy change as a result of professional development. The third chapter described the conceptual framework. The fourth chapter explained the method of the mathematics program evaluation study, its design and instrumentation, the fifth chapter showed findings, and the final chapter had a discussion about findings, and provided implications related to improving this professional development program.

Definition of Terms

The following operational definitions were used in this study:

Adult Learning: "the process of adults gaining knowledge and expertise" (Knowles, Holton, III, & Swanson, 2005, p. 174)

Evaluation: "The systematic investigation of merit or worth" (Guskey, 2000, p. 41)

Pedagogy: the art or science of teaching; tools for learning; "the 'how' of teaching" (Curtiss-Williams, 2009)

Professional Development: "a comprehensive, sustained, and intensive approach to improving teachers' and principals' effectiveness in raising student achievement" (Sec. 9101 ESEA of NCLB Law, 2001)

Self-efficacy: "one's judgment about his or her ability to complete a task; one's perception of his or her capacity or power to produce a desired effect" (Bandura, 1993)

Social Learning Theory: " is the view that people learning by observing others" (Bandura, 1993)

Teacher-efficacy: "the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplishing a specific teaching task in a particular context" (Tschannen-Moran, Wooldfold Hoy & Hoy, 1998, p. 68)

Limitations

The researcher noted the following limitations of the evaluation: (a) The issue of researcher bias will be a limiting factor in this evaluation. Although the researcher was not directly involved in the daily activities or part of the program's staff, she was involved with the proposal design for the program. (b) This study was limited to a small number of elementary teachers; 25 attended the first project summer institute, and 50 attended the second summer institute, with 13 teachers attending both summer institutes. Not all teachers completed the pre and post assessments or follow-up interview questions. (c) The study was limited to teacher perceptions of the professional development experiences and based on teacher self-report. (d) It is possible that the professional development program was not delivered or received as intended. It was assumed that the project staff, business partners, and higher education math content professors were committed to the success of the program. (e) It was also assumed that the higher education professors could assist teachers in improving their knowledge and teaching skills, as well as the teacher participated in the program because they desired to be better teachers. (f) The biggest threat to the validity of this evaluation is the scarcity of reliable and valid instruments to assess the program outcomes. For example, in this program, the higher education professors used a self-made assessment to measure improved mathematical content knowledge. This pre-post measurement demonstrated if the teacher participant did get more mathematic problems correct on the post assessment than on the pre-assessment, but it did not allow for tracking the development of teacher knowledge throughout the ten-day summer institute, or to identify the factors that contributed to the growth made by the participant. Another example is the Survey of Enacted Curriculum survey given to teacher participants. This survey, which was given pre-and post-program to measure efficacy and teacher preparedness, is based on prior well-tested survey instruments (i.e. TIMSS, NAEP, and National Survey of Science and Math Education), and has been field tested to ensure reliability and validity of the data, but the researcher was only able to use a few items from the entire survey that was related to what was measured in this program evaluation. Pulling out test items most likely reduced the level of validity for this instrument. (g) Lastly, a threat to the validity of this evaluation is the fact that although the program was designed to initiate change in teachers' attitudes, beliefs, and perceptions, and better prepare them to teach math content by expanding their content knowledge, there were no outcomes that measured if in fact the teacher made changes in their classroom practices.

Chapter 2: Literature Review

This review begins with a historical look at how professional development in education has evolved over the past several decades. It provides a conceptual definition of professional development, including structural features researchers have identified as key to effective teacher growth. The review also considers the relationship between characteristics of professional development and teacher growth. Factors related to expertise development, such as in teacher efficacy, pedagogical understanding, and content knowledge are considered. Particular attention is given to studies related to professional development activities in mathematics. Theories related to cognitive learning and adult learning are also reviewed in order to understand the cognitive side of teacher learning.

Professional Development Historical Perspective

From educational researchers to school administrators and teachers, there has been much discussion and debate over what it takes to develop effective educators who are able to transfer content knowledge to students (Darling-Hammond, 2005). Professional development has been a part of teaching since the early days of formal education. It has evolved throughout time; nevertheless, discussions and debates over content and characteristics of professional development have been waged with inconclusive results (Guskey & Yoon, 2009). One certainty remains; professional development programs in previous years have not resulted in meaningful changes to improve math instruction or teacher classroom practices. To examine why this is so, one needs to look at "workshops" or "in-service" with a historical perspective.

In a review of literature, it becomes apparent that the focus of past professional development experiences paralleled with society influences of the time. For example, in the 1950s and 1960s teacher training, called workshops, focused on content knowledge. Teachers were expected to learn more mathematics, science and writing because of the Sputnik challenge (Fullan, 2007). When the Soviet Union launched the first artificial earth satellite, mathematics and science education policies and programs for U.S. changed in public schools. The fear that the U.S. was falling behind Russia in space exploration drove America to push for new direction in science education, and therefore, teacher training drastically changed to incorporate more content knowledge, and the amount of resources for professional development increased (Fullan, 2007). During the Sputnik era, the United States funded higher education institution projects for teachers to attend during the summer to improve the knowledge base of science and mathematics. During these intensive trainings, teachers were exposed to new curriculum that centered on the conceptually fundamental ideas and the modes of scientific inquiry and mathematical problem solving. Although the goal of these trainings was to find new ways of teaching math and science, the outcome was disappointing. Holly, (1989) found that many teachers went back to their classrooms to teach the newly learned concepts, only to discover that these teachers still struggled with the concepts themselves.

Blackman (1989) reported that education policies developed by the National Staff Development Council in the late 1970s and early 1980s signaled a change in the conception of continuing professional growth that emphasized not only deficiencies in mathematics and science content knowledge, but also added the need to integrate social aspects into instruction such as diversity training, strategies to improve graduation rates, and awareness of diverse socioeconomic conditions in the schools (Garet, et al., 1999). One type of professional development activity that had the most systemic changes at the school level involved teachers collectively studying classroom practices (Cochran-Smith & Lytle, 1992).

According to Sparks and Loucks-Horsley (1990), professional development made additional improvements in the 1980s. Federal and State legislatures became more involved in local school district policy, and viewed professional development as a key aspect of school improvement efforts. This legislative interest was largely due to the lessons learned in the previous decades, as well as a response to the contentious claims leveled in *A Nation At Risk (*National Commission on Excellence in Education, 1983). *A Nation at Risk* made claims that many teachers did not have the knowledge, skills, and training they needed to teach subjects such as math to students who could attain higher than average scores in college entrance examinations. The report called for teachers to become better prepared in both content and teaching practices. This laid the groundwork for teacher trainings to be more rigorous, which meant that teachers would not only work to increase subject-matter knowledge, but also improve their pedagogical practice intended to boost student test scores (National Commission on Excellence in Education, 1983).

Over the last two decades, there has been a movement toward more integrated and site-specific approaches to teacher learning. These approaches (i.e., professional learning communities, instructional coaches, critical friends' groups, weekly data team meetings, peer coaching and lesson study) have achieved mixed results (Garet, Porter, Desimone, Birman, & Yoon, 2001). Collectively, what we know from research about effective professional development is that there are identified characteristics of activities that influence whether or not teacher participants gain new knowledge and transfer their learning back to the classroom (Wang, Frechtling, & Sanders, 1999).

Professional Development Characteristics

Guskey (2000) encourages school leaders to recognize the importance of continuous growth and learning for adults in schools. He explains that learning for teachers should be high quality and include experiences that enhance teacher content knowledge and content pedagogy. Guskey (2000) defined professional development as "those activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students" (p. 16).

Even though a few studies have provided strong evidence, the existing evidence does point to common characteristics found with effective professional development. Several scholars have studied and identified these effective characteristics of high quality professional development (Blank, de las Alas, & Smith, 2008; Darling-Hammond and McLaughlin, 1995; Darling-Hammond, & Richardson, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet et al., 2001; Guskey, 2003; Porter, Garet, Desimone, Birman, 2003; Yoon, Duncan, Lee, Scarloss & Shapley, 2007). There is even considerable evidence regarding effective strategies to build math instruction (Loucks-Horsley, Hewson, Love, & Stiles (1998); Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2010). The findings of a meta-analysis, titled *Reviewing the Evidence on How Teacher Professional Development Affects Student Achievement* (Yoon et al., 2007) revealed only nine out of 1,300 studies met the What Works Clearinghouse standards that addressed the effect of professional development on student learning outcomes. Researchers described these nine studies as varying in quality and effect for student learning, but several common elements of professional development emerged. The characteristics of high quality professional development consistent with those identified by the above-mentioned researchers include:

- alignment to school goals and standards;
- core content focus and modeling of teaching strategies;
- collective participation and collaboration among teachers;
- active learning to include opportunities to practice new teaching strategies;
- outside expert involvement; and
- sufficient time and duration.

Although there was no strong, valid, or scientific evidence demonstrating the effectiveness of the above characteristics, each was present in a number of studies and noted as contributing to the effectiveness of professional development. Some of the characteristics also align with principles of adult learning theory. For instance, adults learn best through experiences in a supportive environment. Modeling and participation can provide helpful learning experiences. Offering learning opportunities to teachers that draw on experiences, such as collaborative activities or open-ended questioning, can allow learners to reflect, broaden their perspective of the content, and learn from another (Knowles, 1980).

Alignment to School Goals and Standards

The first characteristic of high quality professional development is alignment of activities to school goals and standards. It is common sense to think that teachers who receive consistent messages regarding what to teach and the best ways to teach it are most likely to improve in their classroom instruction. According to several researchers (Cohen and Hill, 2000; Garet et al., 2001; Grant, Peterson, and Shojgreen-Downer, 1996), professional development activities are more likely to be effective if they are part of a coherent program of ongoing learning activities, and the activities are aligned to standards. Unfortunately, many math teachers learned to teach using a model of teaching and learning that focused heavily on memorizing facts, without emphasizing deeper understanding of subject knowledge. Changing this idea of teacher instructional practice is difficult. If professional development activities are going to have a significant, positive effect on teachers' self-reported increases in knowledge and skills, then they must build on what teachers have learned in related professional development trainings, and aligned to data analysis and state standards (Youngs, 2001).

Birman, Le Floch, Klekotka, Ludwig, Taylor, Walters, et al. (2007) found in a study with teachers concerning professional development experiences, that roughly sixty-seven percent of general education teachers reported in 2005-06 that their training time was designed to support state or district standards, but few of these teachers reported that what they learned was based on what they had been taught in earlier professional experiences. This is a problem often seen in districts. Garet et al. (2001), found that teachers reported greater change in their knowledge and skills when professional learning activities were "built on what the teachers had already learned in related professional learning activities."

An example specific to math teachers would be to provide on-going opportunities and support to attend professional development activities that demonstrate research-based best practices that are aligned to the instruction of mathematics state standards. This kind of professional development helps teachers grow in content knowledge and at the same time improve pedagogical skills to teach the standards. In this way, focusing on specific standards during activities will help teachers determine their strengths and weaknesses, which enables them to have the time to receive support and focus on continually improving their practice. (Hawley & Valli, 1999; Loucks-Horsley et al., 1998).

Content and Pedagogical Knowledge

The most frequently cited characteristic for effective professional development was enhancement of teacher content and pedagogical knowledge (Guskey, 2003). The ultimate goal of professional development is to increase student achievement (Mundry, 2005; Porter et al., 2003; Quick, Holtzman & Chaney, 2009); instructionally and content focused professional development supports teachers toward that goal. This suggests that professional development focus on what content students are expected to learn, and how students learn the subject matter that can result in better teaching and better student achievement (Shulman, 1987).

Unfortunately, as much literature as there is on professional development, little attention has been given to what teachers actually learn in the professional development activities. Many training activities devote a lot of time to the subject matter that teachers are expected to teach and the teaching methods teachers are expected to employ. Some activities are intended to improve teacher knowledge of subject matter, and some are designed to improve general pedagogy or teaching practices, such as classroom management, lesson planning, or grouping methods (Darling-Hammond & Richardson, 2009). Some are intended to improve what Shulman (1987) has termed “pedagogical content knowledge,” which are teaching practices in specific content domains, such as teaching multi-digit addition in elementary mathematics. Activities may also focus on helping teachers use particular curriculum materials (e.g., new math textbooks) or prescribed teaching strategies (e.g., specific questioning strategies; examining student work and build lesson plans around common mistakes).

Findings from Joyce and Showers (1982), Cohen and Hill (2000), and reviews by Kennedy (1998) and Hawley and Valli (1999), show professional development activities that are content focused improve the knowledge base for teachers thus giving them an increased sense of teacher efficacy. Teachers involved in the findings reported that their increased competence positively affected their student-learning outcomes. These findings echo research by Guskey (1995), which found that teachers who attended professional development with a goal to improve their content knowledge, tried out knew practices on their students that led to favorable results, resulted in improved teachers' attitudes and led to change in practice.

In examining professional development devoted to subject, content focus, skill level, and form, Kennedy's (1998) review analyzes the relative effects on student outcomes from professional development programs for math and science. She concluded, "Programs whose content focused on teachers' behaviors, demonstrated smaller influences on student learning than did programs whose content focused on teachers' knowledge of the subject, on the curriculum, or on how students learn the subject" (p.18). Therefore, if teachers do not understand the content of what they teach, they will never understand if students understand the subject matter, or be able to recognize signs of learning or signs of confusion.

Collective Participation

A third characteristic of high quality professional development is collective participation for teacher participants. A few researchers (Ball & Cohen, 1999; Garet et al., 2001; Corcoran, et al., 2003; Darling-Hammond & Richardson, 2009) have studied the importance of collaborative and collegial learning environments that help develop communities of practice and promote school change beyond individual classrooms (Darling-Hammond & Richardson, 2009). There is a growing interest in professional development designed for groups of teachers from the same school, department, or grade level (Birman et al., 2000). This is partly because teachers value opportunities to learn from one another (Lieberman & Pointer Mace, 2008). Professional development designed for groups of teachers has a number of potential advantages. First, teachers who work together are more likely to have the opportunity to discuss concepts, skills, and problems that arise during their professional development experiences. Second, teachers from the same school, department, or grade are likely to share common curriculum materials, course offerings, and assessment requirements. By engaging in joint professional development, they may be able to integrate what they learn with other aspects of their instructional context. Third, teachers who share the same students can discuss student needs across classes and grade levels. Finally, by focusing on a group of teachers from the same school, professional development may help sustain changes in practice over time, as some teachers leave the school's teaching force and other new teachers join the faculty (Desimone et al., 2002).

Collective participation in the same activity can provide a forum for debate and improving understanding, which increases teacher capacity to grow (Ball, 1996). Furthermore, Knapp (1997) emphasizes that change in classroom teaching is a problem of individual learning as well as organizational learning, and that organizational routines and the establishment of a culture supportive of reformed instruction can facilitate individual change. Little research is available on the effects of collective approaches to professional development, but there is some evidence that it can be effective in changing teaching practice. Newmann, King and Youngs (2000), in a study of 24 restructuring schools, noted that in more successful schools, professional development was focused on groups of teachers within the school and used internal as well as external expertise. In other words, professional development activities took advantage of local skills and sharing of effective practice.

Active Learning

Another noted characteristic for quality professional development concerns the opportunities provided by training activities for teachers to become actively engaged in meaningful discussion, planning, and practice (Loucks-Horsley, Hewson, Love, & Stiles, 1998). The importance of active learning goes back to Aristotle. He once said, “For the things we have to learn before we can do them, we learn by doing them.” Research has shown that teachers report greater changes in their instructional practice as a result of professional learning activities that involve their active participation and engagement (Desimone et al., 2002; Garet et al., 2001). According to Garet et al. (2001), Lieberman (1996), and Loucks-Horsley et al., (1998), active participation can include observing other teachers, or being observed; planning curriculum for classroom implementation; reviewing student work; or engaging in meaningful discussion, practice and reflection.

Analyzing data from the National Science Foundation Teacher Enhancement Program, Supovits and Turner (2000) found that the quantity of professional learning activities relates to how much teaching practice and classroom culture change. Although Garet et al. (2001) found that opportunities for active learning had a small positive effect on teacher knowledge and skills, several observers have documented that when teachers have the opportunity to become actively engaged in their own learning through observations, close study of student work in collaboration with colleagues, and joint curriculum planning, they are more likely to improve their practice (Lieberman, 1996; Loucks-Horsley et al., 1998).

A study made by researchers (Birman, Desimone, Porter and Garet, 2000), involving a survey of more than 1,000 teachers who participated in professional development sponsored in part by the federal government's Eisenhower Professional Development Program reported active learning opportunities such as observing other teachers and being observed, planning classroom lesson plans, and reviewing student work encouraged teachers to change classroom practice.

Another example of a successful program illustrating the importance of active learning is involved a group of sixth grade teachers from a school in Texas (Lieberman, 1996; Loucks-Horsley et al., 1998). The professional development activities for this math integration program that was offered by a local university included teacher participants who enrolled in a six-week summer institute. Teachers kept journals, learned new teaching strategies, live modeling, and instructors videotaped the teacher participants in the classroom and provided feedback. Professional development sessions which aim to make teachers aware of a concept have been shown to be more successful when they allow teachers to learn the concept in varied, active ways (Richardson, 1998).

Outside Expertise Involvement

Many quality professional development activities are led by outside experts who have deep technical knowledge that is specific to an area of instruction. The use of outside experts can support greater teaching knowledge skills (Desimone et al., 2002; Garet et al., 2001). Generally, experts are used in training of trainers, for peer coaching to lead specific sessions or to advise on specific problem areas, and when an expert demonstrates the new practice, teacher participants are more open to adopting it into their own classrooms (Cohen & Hill, 2001; Desimone et al., 2002).

Darling-Hammond and McLaughlin (1995), identify curricular development as an area where university partnership can be helpful with K-12 teachers in making curriculum development changes. Desimone et al., (2000) support this belief. They claim that when there is alignment and coordination from postsecondary institutions with K-12 teacher professional development activities, a coherent reform takes place. Relationships and partnerships established with outside experts can "create new, more powerful kinds of knowledge about teaching and schooling" Darling-Hammond and McLaughlin (1995). Another analysis by Guskey and Yoon (2009) found the professional development efforts that brought about the most improvements in student learning were those who brought in either program authors or researchers who presented ideas directly to teachers and then helped facilitate implementation.

By working together to improve and change instructional practices, the higher education mathematics content professors get insight into teacher needs and teachers in turn gain insight on what they need to learn in order to teach more content (Porter, 1987). The learning process for teachers who attend professional development in order to change instructional practices may be difficult for some, while other teachers are eager to implement a changed methodology after attending a learning institute (Tschannen-Moran et al., 1998).

Duration

The last characteristic of high quality professional development refers to the length of time for the training. Educators need time during professional development to deepen their understanding. “Almost all of the recent literature on teacher learning and professional development calls for professional development that is sustained over time” (Garet et al., 2001, p. 919). Several researchers (Birman et al., 2000; Darling-Hammond & Richardson, 2009; Garet et al., 2001; Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgeway, & Bond, 1998; Yoon et al., 2007) believe that the duration of professional development is related to the depth of teacher change, especially if it is focused on content.

Garet et al. (2001) outlines two specific ways that the duration plays an integral part of effective professional development: (1) in-depth discussion concerning the content, and ways to teach the content can take place, and (2) activities extended over days that encourage the teachers to try out newly learned practices, obtain feedback, and engage in reflective discussion about their own teaching. Darling-Hammond and Richardson (2009), citing Yoon et al. (2007), state that in the What Works Clearinghouse studies, any professional development lasting 14 hours or less showed no effects on learning. Furthermore, Yoon et al. (2007) found that the largest effects were taken from programs offering 30 to 100 hours of professional development over a six to 12-month period. In fact, in a study analyzing the effects of a science program on teacher’s practice, researchers found that teachers with 80 hours or more of professional development were significantly more likely to use the teaching practice they learned than teachers who had less than 80 hours of training (Corcoron, et al., 2003). These findings validate research on teacher learning, which shows mastery of a new skill is a time-consuming process for teachers.

Effective professional development provides teachers with opportunities to practice new skills and practicing skills requires adequate time to experiment, study, and make sense of the results (NSDC, 2004). Research shows that changes in teaching practices involve a continued process that takes place over time, and that follow-up professional development sessions are important for teachers to address their personal concerns about managing and implementing their new learning (Loucks-Horsley & Stiegelbauer, 1991). Effective professional development allows time following the initial training for teachers to reflect critically on their practice, and to translate their new knowledge and beliefs about several things including content, pedagogy and learners (Darling-Hammond & McLaughlin, 1995).

There are a very limited number of research studies that has been conducted on the effects of professional development, but there is guidance on characteristics of effective professional development activities. Even knowing the characteristics of high-quality professional development (i.e., alignment to school goals and standards; core content focus and modeling of teaching strategies; collective participation and collaboration among teachers; active learning to include opportunities to practice new teaching strategies; outside expert involvement; and sufficient time and duration) it is clear that many professional development activities do not have features of high quality. Several reasons may support why activities lack these characteristics. First, including all of what research tells us in a professional development activity is challenging. Second, providing these activities with some of the components needed is expensive. Garet et al. (2001) estimated from a study that was conducted an average of $1,512 per teacher was spent to provide a high-quality professional development experience for math and science teachers. Lastly, the necessary span of time it takes for teachers to participate in active learning opportunities is greater than the span of time they provide instruction to a group of the same students; therefore, testing student achievement is not possible.

Effects of Professional Development on Teachers' Practices

The professional development historical perspective, and the empirical evidence describing the structural characteristics of effective professional development have been discussed, but the research on translating new knowledge and skill into practice, known as teacher change, is limited. According to Guskey (1998), it is difficult to guarantee professional development effectiveness merely by ensuring the presence of a set of structural characteristics. Guskey (1998) recommends measuring teacher satisfaction, learning, and behavior.

Education research on teacher professional development has used self-efficacy and adult learning theories to explain the social and psychological process under which changed instructional practices occur. Because this evaluation has a mathematics focus, reviewing the literature on teacher pedagogy and pedagogical tools can also help explain the change process made by teachers in their mathematics curriculum and instructional practices.

In spite of the evident association between teachers' self-efficacy and teacher and student outcomes, little is known about how change takes place in relationship to years of teaching experience. Researchers who have studied teachers' motivation beliefs (Tschannen-Moran & Woolfolk Hoy, 2007; Wolters & Daugherty, 2007) believe teachers' self-efficacy is most easily influenced in the early years of a teacher's career and more firmly established as the teacher gains experience. These same researchers also discovered that late career teachers add additional tests based on their classroom experience that influences their motivation beliefs.

Teacher Change and Self-Efficacy Theory

The development of self-efficacy can be seen as an important motivational construct for promoting teacher change. According to Gist and Mitchell (1992), "People who think they can perform well on a task do better than those who think they will fail (p. 183)." Bandura's (1977) notion on self-efficacy, developed from social cognitive theory, is defined as "belief in one's capabilities to organize and execute the courses of action required producing given attainments (p. 191)." In the context of mathematics education, this would be characterized as a teacher's belief that he or she can effectively teach mathematics. Bandura also includes a belief known as 'outcome expectancy.' Bandura stated, "…outcome expectation is a judgment of the likely consequences such performance will produce" (p. 21). An example is an elementary math teacher's belief that if math is taught effectively, the students will learn math.

According to Bandura's (1977) construct of reciprocal determinism, a person's mental function is influenced by personal and social factors. In other words, Bandura's (1977) research shows that the formation of self-efficacy beliefs combines factors such as behavior, cognition, and the environment in order to determine the efficacy judgment. Evaluating shared beliefs of how teachers rate their ability to teach mathematics concepts and content after receiving professional development can provide direct evidence supporting individual teacher efficacy beliefs. Research supports the idea that teachers need to feel efficacious in their work in order to create a learning environment that supports instructional-change initiatives (Smith, 1996).

Research findings show teachers who specialize in either mathematics or science, are more confident in their ability to have a positive effect on student learning (Chang, 2009). Few studies reveal the same sort of efficacy beliefs among elementary teachers and teachers with little experience (Woolfolk Hoy & Burke-Spero, 2005). Polettini (2000) found that elementary mathematics teachers who had prerequisite knowledge of mathematics education and experience in teaching elementary mathematics showed improved efficacy following professional development training. As predicted by Bandura (1997), new elementary teachers, or teachers who had little or no experience teaching mathematics, revealed little or no improvement in efficacy (Polettini, 2000). According to Tschannen-Moran et al., (1998), the changes in efficacy beliefs among teachers participating in professional development are difficult to produce and sustain. With continued support, feedback, and reinforcement, along with time for teachers to begin witnessing evidence of improved student learning, teacher efficacy improves (Tschannen-Moran et al., 1998). Furthermore, according to a change that holds great promise for increasing a program's effectiveness is to allow time for teachers to use the new practices continuously and ongoing (Huberman & Miles, 1984).

Teacher Change and Adult Learning Theory

Malcolm Knowles is best known for his efforts to create a unified theory of adult learning. Knowles' (1980) attempts to create a theory to differentiate learning in childhood from learning in adulthood. Knowles concluded that adult learning is determined by the situation and not as much by the age of the learner (Knowles, 1980). Knowles studied the process elements of adult learning. He proposed five key assumptions about adult learners:

(1) Adults are motivated to learn as they experience needs and interests that the learning would satisfy;

(2) Learning for adults is life-long;

(3) Experience is the main resource for adult learning;

(4) Adults have a need to be self-directed in their learning; and

(5) Individual differences among people increase with age.

Knowles theorizes that teachers involved in staff training with a goal of learning new knowledge and skills might experience various stages of anxiety, frustration, and often a sense of failure during the process of the activities (Knowles, 1983). Knowles suggests ways to advance teacher learning and avoid negative outcomes.

He argues that the learning experience must be organized around life-application categories and sequenced according to the learners' readiness to learn. In other words, Knowles suggests that professional development activities should focus on providing teachers experiences that they can apply to tasks and problems they would find in the classroom. Knowles' theory would support the idea that teachers see professional development as a way to increase their competence today and be able to apply it tomorrow in their classrooms (Knowles, 1975).

Intrinsic motivation is a necessary prerequisite for adult learners (Csikszentmihalyi, 1997; Maslow, 1965). Working in a group, adult learners are typically self-directed, ready to learn, task-centered, and intrinsically motivated (Knowles, 1983). Effective professional development for teachers supports teacher motivation and commitment to the learning process (Flores, 2005; Fullan, 1995; Guskey, 1995; King & Newmann, 2004; Loucks-Horsley & Stiegelbauer, 1991). Teachers must use professional development as an opportunity to acquire new skills or knowledge (Guskey, 1995). Basing professional development on understanding of the characteristics of adult learners enhances teacher motivation and commitment to the learning process (Guskey, 1995).

Cognitive Development and Professional Development

Another area of adult learning focused on cognitive/intellectual development. Hunt (1975) provided research showing that the cognitive/intellectual development of adults moved from concrete to an abstract stage. This information is useful in evaluating professional development. It shows that those having several years teaching experience were more likely than beginners to have a commitment to self-affirmation rather than to externally generated successes (Trotter, 2006). Experienced teachers were more likely to feel intrinsically satisfied for the professional development experience, and less likely to feel overwhelmed or frustrated with the new learning. Professional development programs should realize the differing needs of targeted audiences to make training more meaningful and transferable into the classroom (Trotter, 2006).

Stigler and Hiebert (1999, 2009) argue that "a little recognized truth in education reform is that every recommendation for improving teaching requires teachers to learn" (p. 142). Theories relevant to adult learning are influential in the development, implementation and evaluation of professional development programs. The teachers desiring a change in student achievement must modify both practice and their underlying values (Darling-Hammond & McLaughlin, 2005). Darling-Hammond and McLaughlin go on to note "helping teachers rethink practice necessitates professional development that involves teachers in the dual capacities of both teaching and learning, and creates new visions of what, when, and how teachers should learn" (2005). Darling-Hammond (1997) states:

> If teachers are to prepare an ever more diverse group of students for much more challenging work—for framing problems; finding, integrating and synthesizing information; creating new solutions; learning on their own; and working cooperatively… they will need substantially more knowledge and radically different skills than most now have and most schools of education now develop. (p. 154)

Adult learners share several characteristics; they are diverse, have various life experiences, educational backgrounds, and personalities (Lawler, 2003). Life experiences of the teacher can influence one's perspective on motivation to engage in professional development activities (Lawler, 1991). Bandura (1997) refers to the cognitive process in which people construct beliefs about their capacity to perform at a given level of attainment as self-efficacy. "Teachers who have had a high number of years teaching tend to seek the meaning of learning, based on the experiences in the classroom, where younger teachers do not always see the need to connect their learning to the here and now and make sense of it" (Taylor, Marienau, & Fiddler, 2000, p. 4).

- In general, through the review of adult learning research and various theories related to adult development research, there were several key themes: Adults used experience as a resource and it cannot be ignored;
- Adults needed to plan their own educational paths based on their interests and their classrooms; and
- The aim of adult education should be to promote individual development by encouraging reflection.

No Child Left Behind's mandate to ensure a highly qualified teacher in every classroom has contributed to the focus on the essential knowledge teachers need to teach mathematics and science content standards (Loucks-Horsley et al., 2010, p. 4). Quick et al., (2009) found that emphasis on instructional strategies over subject area content is not as likely to result in improved student learning outcomes; however, most research shows that effective professional development centers on both subject area content and how to teach it (Lambert, Wallach, Ramsey, 2007; Lieberman & Pointer Mace, 2008; Mundry, 2005; Porter et al., 2003). The little research that has been conducted on the effects of professional development shows how important it is to address substantive content and pedagogy within the teachers' learning program (Garet, Porter, Desimone, Herman & Yoon, 1999).

Although Garet et al. (2001) found that opportunities for active teaching learning had only a small positive effect on teacher knowledge and skills, further research is needed. Several observers have documented that when teachers have the opportunity to become actively engaged in their own learning through observations, close study of student work in collaboration with colleagues, and joint curriculum planning, they are more likely to improve their practice (Lieberman, 1996; Loucks-Horsley et al., 1998).

The notion of improving the art of teaching emerged during the inception of the school reform effort in the 1980s. Particular importance was placed on teacher preparedness in numerous national reports including: A Nation at Risk (NCEE, 1983), Tomorrow's Teachers: A Report of The Holmes Group (1986), The Carnegie Report, and A Nation Prepared: Teachers for the 21st Century (1986). It is difficult for those teachers who did not necessarily decide to teach because of their mathematics expertise to carry out the demands of communicating the knowledge and developing advanced thinking and problem solving among their students (Loucks-Horsley et al., 1998). Many teachers are not prepared to implement teaching based on high standards and they learn to use a model of teaching that focuses on memorizing facts, without focusing on a deeper understanding of subject knowledge (Cohen, McLaughlin, & Talbert, 1993). Teachers must know their subject area content well enough to anticipate student misconceptions, and engage students in learning with more emphasis on understanding the subject matter (Shulman & Sparks, 1992). Knowledge of content, although critical, is not enough. There is strong evidence that pedagogical content and generic pedagogical practices have an effect on student learning (Blank, Alas, Smith, 2008; Mendro & Benbry, 2000; Muijs & Reynolds, 2001; Sanders & Rivers, 1996).

Teacher Change and Pedagogy

What constitutes pedagogy is complex and not easily defined. Watkins and Mortimer (1999) define it as "any conscious activity by one person designed to enhance the learning of another" (p. 3). Alexander (2003) has his own preferred definition, which suggests that pedagogy requires discourse. "Pedagogy is the act of teaching together with its attendant discourse. It is what one needs to know, and the skills one needs to command in order to make and justify the many different kinds of decisions of which teaching is constituted" (p. 3). For this evaluation, pedagogy is defined as the art or science of teaching, tools for learning, and the 'how' of teaching (Curtiss-Williams, 2009). A consensus from those who study teacher practices in the areas of science and mathematics consider that teacher knowledge is fundamental to pedagogy, but often teachers' pedagogy practice is reflected more on their own experiences as a student than on that of a teacher (Blanks et al., 2008; Prestage & Perks, 2000; Shulman, 1986).

Content Knowledge Pedagogy

The National Board for Professional Teaching Standards (1991) defines content pedagogy as follows:

> Content pedagogy refers to the pedagogical (teaching) skills teachers use to impart the specialized knowledge/content of their

> subject area(s). Effective teachers display a wide range of skills and abilities that lead to creating a learning environment where all students feel comfortable and are sure that they can succeed both academically and personally. This complex combination of skills and abilities is integrated in the professional teaching standards that also include essential knowledge, dispositions, and commitments that allow educators to practice at a high level (see http://www.nbpts.org/).

Professional development in which participants are given the opportunity to learn new classroom practices in the contexts within which those practices will be used is far more effective than more traditional methods of professional development (Birman et al., 2000).

Technological Pedagogy

In 2009, President Obama launched the Educate to Innovate campaign to improve the participation and performance of all U.S. students in science, technology, engineering, and mathematics (USDE, 2010). "This innovation requires leveraging technology to ensure the maximum opportunity for students to learn" (Gee, 2004, p. 4). Research indicates that, despite the many efforts researchers and educators have invested over the years in preparing teachers in the educational uses of technology, teachers continue to lack the skills and knowledge needed to teach successfully with technology (Angeli & Valanides, 2005; Niess, 2005). Technological literacy has fast become one of the basic skills of teaching, and the increase in the availability of electronic resources in schools and classrooms makes it important for teachers to be prepared to effectively integrate technology into their instructional practices. Unfortunately, the evidence suggests that technology is often poorly integrated with other classroom instructional activities (Becker, 2001; Hart, Allensworth, Lauen, & Gladden, 2002). In the area of teaching mathematics, technology can be a key mechanism when looking beyond the acquisition of factual and procedural knowledge. Evidence suggests that educational improvement comes about through sound practices of technology instruction (Goldman, Lawless, Pellegrino, & Plants, 2005).

Despite schools having an abundance of computers, the evidence is mixed as to whether overall student achievement has notably increased, or the achievement gap has visibly narrowed as a result of the use of technology (Cuban, 2001; Healy, 1998; Wenglinsky, 1998; Wilson, 1999; Yau, 1999). Research does seem to support a claim that using technology increases efficacy (Fouts, 2000). WestEd (2002) concluded that there is convincing evidence that the educator's role, the preparedness of the educator, and the level of student access to the technology, all influence technological effectiveness.

Based on the historical review of professional development, studies revealing the key characteristics of professional development, and theories related to how people learn, it has become easier to determine if professional development programs have changed beliefs and practices (Rowan, Correnti, & Miller, 2002). Research also suggests that teachers who know their mathematics content and use effective instructional strategies tend to produce achievement gains (Wenglinsky, 2002).

Chapter 3: Logic Model for Professional Development Program

An integrated theoretical framework of social cognitive theory and adult learning theory was used to examine how well components of the professional development program in this study align with the sources of efficacy, instructional preparedness to teach mathematics content, and increased math content knowledge. Bandura's (1993) social cognitive theory fits with the direct focus on improving efficacy, whereas Knowles (1975) adult learning theory accounts for activities purposefully designed to enhance teacher preparedness to deliver high quality math instruction. An overview of these theories is provided before using them to interrogate the professional development program's logic model.

Social Cognitive Theory

Bandura's social cognitive theory is based on the principle of learning through observing others' behavior. Specifically, it explains human volition and action as a function of the triadic relationship between behavior, personal factors, and the environment (Figure 1). As Bandura (1977) argued, "Personal and environmental factors do not function as independent determinants; rather they determine each other. Nor can 'persons' be considered causes independent of their behavior. It is largely through their actions that people produce the environmental conditions that affect their behavior in a reciprocal fashion. The experiences generated by behavior also partly determine what a person becomes and can do which, in turn, affects subsequent behavior (p. 9)." Figure 1 demonstrates the reciprocal causation model.

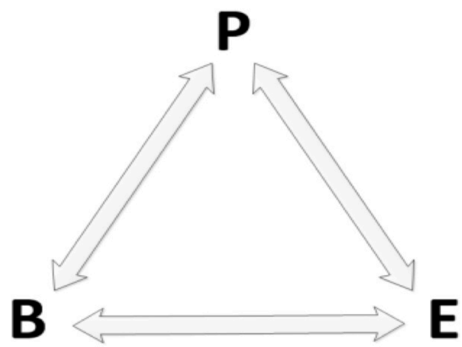

Figure 1. Triadic causality and reciprocal determinism (Bandura, 1977 p. 10), **B** signifies behavior; **P**, personal factors; **E**, the environment.

According to Bandura (1977), a person forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. Bandura explains not all behaviors observed will be remembered without certain influences in place, such as motivation and the enhancement of self-efficacy beliefs (Bandura, 1977).

Self-efficacy is a cognitive belief formed overtime and influenced by personal and environmental factors. Bandura defines self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1977, p. 3). There is evidence that teachers with high level of self-efficacy give more time to academic activities and provide more guidance to students than low efficacy teachers (Gibson & Dembo, 1984). Also, higher efficacy teachers are more likely to be innovative and experiment with their teaching (Guskey, 1988).

> Teacher efficacy has proved to be powerfully related to many meaningful educational outcomes such as teachers' persistence, enthusiasm, commitment and instructional behavior, as well as student outcomes such as achievement, motivation and self-efficacy beliefs (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783).

The formation of efficacy has relevance for the professional development program in the center of this study. Efficacy beliefs grow and contrast through four main sources of information (Adams & Forsyth, 2006). First, past mastery experiences have been identified as the dominant force in efficacy beliefs. Effective actions and practices beget future effectiveness. The opposite also rings true – performance troubles raise doubts and questions that undermine future action (Bandura, 1993, 1997). Second, vicarious experiences, or learning by observing successful performance by similar others, have positive effects on one's confidence to perform certain tasks. Third, social persuasion in the form of generative feedback and support can also instill confidence. Finally, affective states oriented toward optimism and hope also supplies energy for efficacy beliefs (Adams & Forsyth, 2006).

With the sources of efficacy in mind, effective professional development experiences would place teachers in an environment where they experience small successes, observe effective performance by others, receive relevant and meaningful feedback on their performance and experience the psychological safety to take risks that can lead to better practice. Bandura (1997) warned that producing positive changes in established efficacy belief require that all four sources work in combination with each other. He also suggested that when people gain new skills and have experiences that challenge their low estimate of their capabilities, they "hold their efficacy beliefs in a provisional status, testing their newly acquired knowledge and skills before raising their judgments of what they are able to do" (Bandura, 1996, p. 83).

Adult Learning Theory

Like social cognitive theory, adult learning theory explains how new behaviors form out of a social-psychological process that centers on the acquisition and internalization of information (Knowles, 1975). Malcolm Knowles is considered the founder of the adult learning theory. He studied the processual elements of adult learning during the 1950s when he was the executive director of the Adult Education Association of the United States of America. He wrote the first major accounts of informal adult education and the history of adult education in the United States (Knowles, 1980). Furthermore, Malcolm Knowles' work and written text while he was on staff as an associate professor of adult education at Boston University and later at North Carolina University, developed courses around 'the andragogical model' (Knowles, 1980). Knowles' attempt at the development of a distinctive conceptual basis for adult education and learning via the notion of andragogy became very widely discussed and used. Based on his evidence, Knowles (1975) proposed five key assumptions about adult learners:

(1) Adults are motivated to learn as they experience needs and interests that the learning would satisfy;
(2) Learning for adults is life-long;
(3) Experience is the main resource for adult learning;
(4) Adults have a need to be self-directed in their learning; and
(5) Individual differences among people increase with age.

Based on Knowles' assumptions in relationship to teacher professional development, a teacher might experience various stages of anxiety, frustration, and often a sense of failure during the process of the training activities (Knowles, 1983). To help teachers through this process, Knowles' theory would support the idea of professional development activities that would provide teacher experiences they can apply to tasks and problems they would find in their own classroom (Knowles, 1975). For example, the first thing that needs to happen to ensure teacher participants improve their learning, is to tell the teacher participants why they need to learn something before undertaking the new learning (Knowles, Holton, & Swanson, 2005). According to Knowles' theory, adults believe they are responsible for their lives (Knowles et al., 2005); therefore, they need to be seen and treated as capable and self-directed. Facilitators of professional development should create environments where adults develop their latent self-directed learning skills (Brookfield, 1986). According to Knowles (2005), adults are ready to learn things they need to know and do in order to effectively cope with real-life situations. Tapping into teacher classroom experiences through experiential techniques (e.g., discussions, simulations, problem-solving activities, or case methods) is a way to promote this learning (Brookfield, 1986; Knowles et al., 2005; McKeachie, 2002; Silberman & Auerbach, 1998).

Knowles' assumptions reveal adults are task-centered and problem-centered in their orientation to learning (Knowles et al., 2005). In other words, they want to learn what will help them perform tasks or deal with problems they confront in everyday situations and those presented in the context of application to real-life (Knowles et al., 2005; Merriam & Caffarella, 1999). Thus, when designing professional development for teachers, it is necessary to be wary of prescribing any standardized approach to facilitating learning, and base training on the participants' experiences and interests

(Brookfield, 1986). Understanding the five assumptions in andragogy prepares facilitators to create this type of successful training.

The program logic model used in this study (Figure 2) depicts the design of the program and assumptions under which the professional development experience is intended to function. The outcomes of increased efficacy for math instruction, instructional preparedness, and increased math content knowledge are believed to be a function of a professional development context that engages teachers in active learning through the activities of a summer institute and continued development during the school year. The specific features of the logic model are described next.

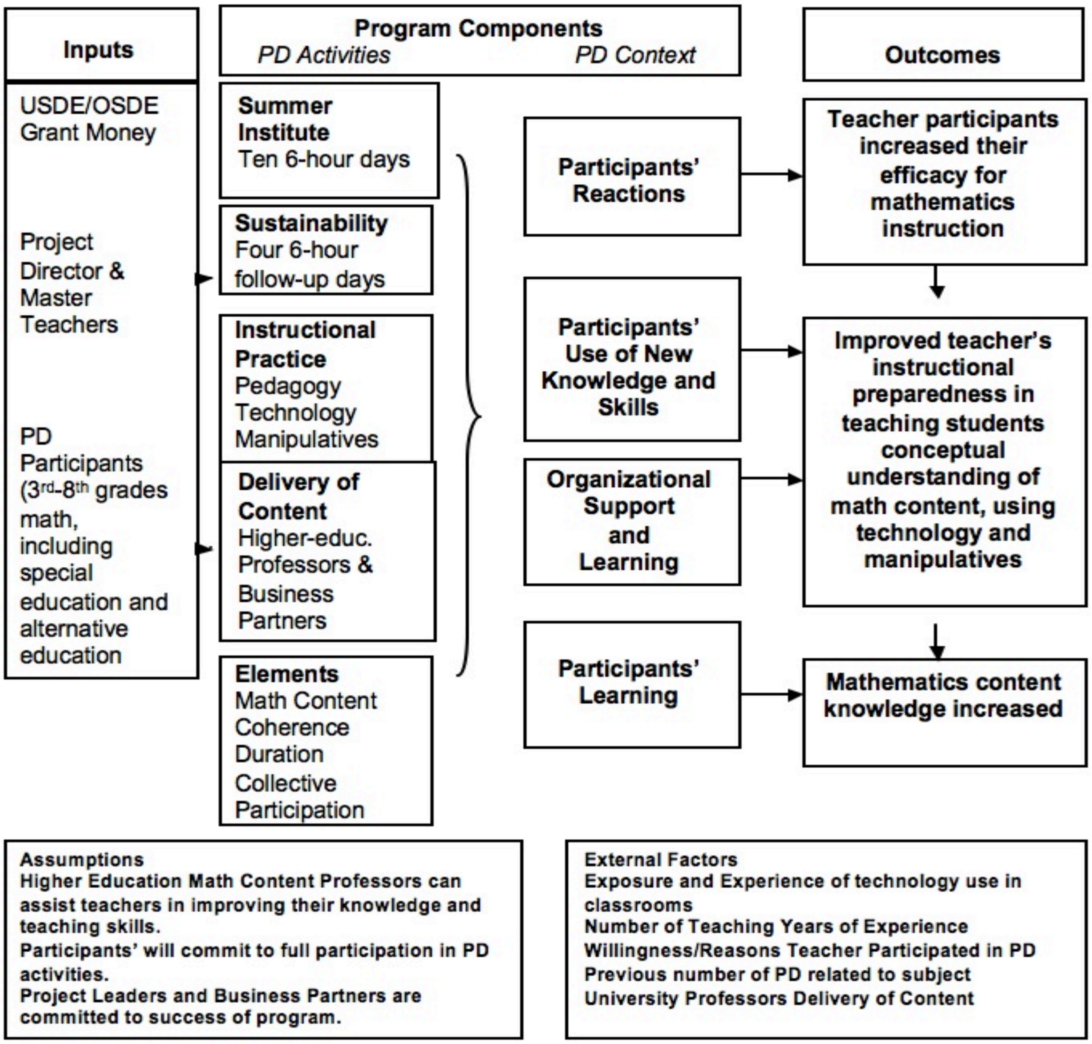

Figure 2. Logic Model for planning the professional development program.

Inputs

The resources that were brought to the program include grant funding, a project director, master teacher, and teacher participants. SDE awarded funding amounts to support necessary costs to carry out the objectives of the projects including salaries, supplies, travel funds, and participants' stipends. The host site for the professional development was in Hominy, OK at the Osage County Interlocal Cooperative (OCIC) office/training center. OCIC provides cooperative services to member districts (i.e., professional development, special education, and grant writing and management). The lead LEA, Hominy Public Schools, contracted with OCIC to provide the project director for projects and management of the program activities. A mathematics teacher from Hominy was designated as a master teacher to assist the project director in program management.

Acceptance criteria for participants included the requirement that applicant teachers must currently be mathematics instructors for students in a regular third through eighth grade classroom, or special education students or alternative education students in third grade through high school. For Project PRIME, administrators from participating districts were encouraged to have at least two teachers submit applications; the three larger districts were given the opportunity to have three participants. If only one teacher submitted an application from a district, other districts were allowed to submit additional applications until the twenty-five participant cap was reached. For Project STAT, the districts were allowed to submit an unlimited number of teacher applications. The final roster of fifty participants included classroom teachers; some were special education teachers, but all taught mathematics to students who were in grades 3-8. In Project PRIME, 20 participants were female and five were male. In Project STAT, there were 47 female teachers and three male participants. There were thirteen teachers who participated in both projects.

Program Activities

Both Projects PRIME and STAT included summer institutes, follow-up training days on non-instructional days (i.e. Saturdays), mathematical expertise from higher education mathematics professors, and business partners who led the learning and practices of instructional strategies. Professional development interventions included an intensive two-week summer institute consisting of ten consecutive six-hour business days, and 60 contact hours. Following each project's summer institute, there were four follow-up training dates during the next nine months, which added 24 contact hours. The business partners led or facilitated the follow-up trainings. The professional development projects supported ongoing virtual learning community activities (e.g. blogging, journaling, E-mail communication, newsletter submissions of classroom activities, etc.), lesson planning, resource sharing, and rapid-response support to teachers' questions. The training sessions also provided tools (e.g. math manipulatives, supplies, camera equipment), and technical support to participants.

To provide instruction for Project PRIME, OCIC contracted with two mathematic professors from Northeastern State University in Oklahoma. Dr. Martha Parrot, and Dr. Steven Wilkerson were the primary instructors for the math summer institute. Both professors were from the College of Education. Dr. Parrot is an associate professor on the Broken Arrow campus; Dr. Wilkerson is a professor on the Tahlequah campus. With positive teacher participant feedback and the partnership relationship established with OCIC, the same two professors served as instructors for Project STAT. The collaboration with higher education supports active learning opportunities in which teachers were allowed to transform their teaching and not simply layer new strategies on top of the old (Snow-Renner & Lauer, 2005). Higher education experts were used to model the new strategies and construct new opportunities for teachers to practice and reflect on them (Garet et al., 2001; Saxe, Gearhart, Nash, 2001; Supovitz & Turner, 2000). Carroll and Mumme (2007), state that the facilitators of professional development learning experiences for teachers must have highly developed facilitation skills, knowledge of the content and how teachers think about the content, and effective strategies for engaging teachers with the content.

The business partners assisted primarily with pre-institute and follow-up training dates. In Project PRIME, Haddock Computer Corporation provided the technology training. Cari Palesano, Haddock's trainer, demonstrated ways to integrate the interactive whiteboards in math instruction. Tara Gotwalt, Community Development Director for Tri-County Technology Center, demonstrated hands-on, real life mathematics learning, and Shelly Hurd, an OCIC employee who contracted with the Aurora Learning Community Association (ALCA) to provide school district training, showed how the ALCA *Comprehend* software can be utilized for data-driven decision making and formative assessment data analysis. Ms. Hurd's goal was to enable each teacher participant to analyze student test data from their recent math classes.

Project STAT enlisted the business partners of Workshop Wizard. Dedra Stafford did pre-session preparation with participants to learn technological tools used during professional development program (i.e. interactive white board). Kandy Kurt, a representative of NASA's Aerospace Education Services Project, led a field trip for participants to the Tulsa Air and Space Museum. Following a tour of the museum, Mike McGlone directed aerospace mathematics activities.

Aurora Learning Community Association facilitated use of a database to analyze test data. NSU professor, Dr. Steven Sargent presented a follow-up session to show participants how to blend literature and mathematics content in preparation for changes made in state standards.

Program Context

According to Guskey, "the first level of professional development evaluation is participant's reactions to the experience" (p. 82). Guskey (2000) says the best way to gather these reactions is through questionnaires containing open-ended questions and rating-scale items. This level of evaluation helps the evaluator determine the level of satisfaction of the teacher. The feelings of joy or pleasure a teacher experiences during trainings enhance a sense of efficacy (Tschannen-Moran et al., 1988), and teachers' self-efficacy beliefs have a vital role in affecting and sustaining their dedication to their job satisfaction and students' academic achievement (Caprara, Barbaranelli, Borgogni, & Steca, 2003).

Guskey also stresses the importance of understanding whether participants were using their newly learned knowledge and skills back into the classroom. Guskey (2000) says this measurement must be made after sufficient time has passed to allow participants to adapt the new ideas and practices to their setting. According to Blank, de las Alas, and Smith (2007), professional development must help teachers develop pedagogical skills to teach specific kinds of content that have strong positive effects on practice and better prepare them to incorporate new strategies within the content they teach (Garet et al., 2001).

Studying the organization characteristics of the professional development is another key factor to evaluating professional development (Guskey, 2000). Guskey (2000) confirms that gathering information on organizational support and change is not always easy, but critical dimensions of organization capacity such as collective commitment, access to knowledge, organizational structures, and resources (i.e., duration of time, materials and technology) is important to collect and analyze to note change efforts and to inform future change initiatives. According to researchers (Garet, et al., 2001; Shields, et al., 1988; Weiss, et al., 1998) studies conducted in the past have identified characteristics of professional development experiences that have had a positive influence on teachers' classroom practice and student achievement. For example, there are studies that suggest the duration of professional development is related to depth of teacher change (Shields, et al., 1998; Weiss, et al., 1998). As far as a mathematics professional development program, there is evidence of improved students conceptual understanding when teachers were trained in the ways students learned certain mathematics content (Cohen & Hill, 1998; Fennema, Carpenter, Franke, et al., 1996).

Guskey (2000) also points out the need to evaluate teacher participant learning. When designing a professional development, it is assumed that participants will learn something from the experience. Guskey (2000) says, "Measures must be based on the learning goals prescribed for that particular program or activity (p. 83)." Guskey (2000) also suggests that pre- and post assessments be used to determine what knowledge and skills participants may possess prior to the program.

Outcomes

Program outcomes were set as internal teacher characteristics associated with effective teaching performance. This includes efficacy for math instruction, instruction preparedness for teaching math in a conceptual way, and increased mathematics content knowledge. Efficacy preparedness and content knowledge represent attributes that enable teachers to apply new competence in the classroom.

Teacher efficacy, as defined by Tschannen-Moran, et al., (1998) is "the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplishing a specific teaching task in a particular context" (p. 68). Some teacher efficacy data from the teacher application were utilized in the evaluation. The applications for both projects asked teacher participants two questions related to their confidence level for teaching mathematics content. The content for Project PRIME was Geometry/Measurement, and Fractions. The content for Project STAT was Data Analysis, and Probability. A third application question was related to teacher confidence in using technology and manipulatives (pre-test data). Pre-test data were collected for the eleven teacher participants who participated in both projects. Twelve to 24 months following the ending of the two projects, post-test data were collected.

Issues of teacher change are central to any discussion of establishing the content of professional development. The desire for any professional development program is to facilitate some degree of change in beliefs, attitudes, or pedagogical ideologies; content knowledge; pedagogical knowledge of instructional practice, strategies, methods, or approaches. Therefore, the professional program components must be attractive to the teacher participant in order for the teacher to gain experiences that the teacher felt successful and increased their self-efficacy.

The goal of this professional development program was for teacher participants to be better prepared to implement into their own classrooms the teaching strategies learned and pedagogy modeled by mathematics professors. The Survey of Enactive Curriculum (SEC), a self-reported survey, was used to measure if the teacher participant improved their preparedness in teaching students conceptual understanding of math content, using technology and manipulatives. The SEC was designed by a collaborative effort of the Council of Chief State School Officers (CCSSO), National Institute for Science Education (NISE) at the University of Wisconsin-Madison, National Science Foundation (NSF), and participating states to analyze classroom practices and curriculum. The SEC was given to teachers prior to the first day of the summer institute (pre-test), and again nine months later following the last follow-up training date (post-test). Six SEC items referenced instructional preparedness: 1) Indicate how well prepared you are to teach math at your assigned level. 2) Indicate how well prepared you are to integrate math with other subjects. 3) Indicate how well prepared you are to provide mathematics instruction that meets mathematics content standards. 4) Indicate how well prepared you are to use a variety of assessment strategies. 5) Indicate how well prepared you are to teach problem-solving strategies. 6) Indicate how well prepared you are to teach mathematics with manipulatives. All of the items include components addressed as objectives during the summer institute of each project (see activities described in Appendix A).

For the purposes of the program evaluation, a working definition of teacher content knowledge was defined as the mathematical knowledge that teachers need to carry out their work as mathematic teachers (Shulman, 1986). The content knowledge was measured using an assessment developed by the project higher education consultants (Appendix B and C) and covering the skills learned during the summer institutes. The assessment was administered to the participating teachers on the first day of the summer institute (Pre-test), and again on the last day of the summer institute (Post-test). The assessment consisted of twenty questions and was a paper-pencil, non-timed test. All mathematic problems were related to content standards covered during the math program.

Qualitative data were also used. According to Guskey (2000), personalized anecdotes and testimonials may offer some evidence to help clarify specific details about the experience of the teacher participant. For this study, this type of qualitative data comes from anecdotal evidence provided in the Google Docs survey. The teachers provided personalized testimonials to questions related to their efficacy and preparedness of mathematics instruction following the professional development program. Specifically, one question asked the teacher participants if the intended outcome of the professional development, which was to increase the subject matter knowledge and teaching skills of mathematics teachers, was accomplished. Another question asked for the teacher to describe the changes in instructional practice that had been made since participating in the professional development.

The professional development program evaluated included two separate projects that were funded by the Oklahoma State Department of Education (OSDE). The projects were internally named Project PRIME (Providing Rich Instruction for Math Educators) and Project STAT (abbreviation for Statistics). Project PRIME began in the summer of 2009, and Project STAT in the summer of 2010. Each project spanned a period of 17 months and each included a 10-day summer institute and four follow-up sessions.

Project PRIME and STAT focused on the content of mathematics. In the fall of 2008, the Project PRIME proposal was submitted to OSDE on behalf of the lead local education agency (LEA), Hominy Public Schools, located in Hominy, Oklahoma. This proposal included a consortium of ten districts (Avant, Barnsdall, Bowring, Caney Valley, Hominy, Osage Hills, Pawhuska, Shidler, Wellston, Woodland, and Wynona). All of these districts are located in northeastern Oklahoma, considered rural, and have a student enrollment ranging from 65 to 890.

The second proposal, Project STAT, was also submitted to OSDE on behalf of the consortium. Hominy Public Schools remained the lead LEA and included the same districts in addition to four others (Frontier, Cleveland, Skiatook, and Anderson). Both projects were similar in design and format, but the number of teacher participants increased from 25 in Project PRIME to 50 in Project STAT. A total of 61 teachers participated in the mathematics professional development program. The OSDE Priority Academic State Standards (PASS) focus of Project PRIME was Geometry/Measurement and Fractions. Project

STAT focused on PASS Data Analysis and Probability standards. These standards were chosen based on performance weaknesses revealed in the Oklahoma Core Curriculum Tests (OCCT). For both projects, the skills covered were challenging for many third through eighth grade students and were considered an essential foundation of algebra (National Mathematics Advisory Panel, 2008).

After award notification from the Oklahoma State Department of Education, program administrators reached out to district administrators to help with recruitment of teacher participants. Teacher participants interested in participating in the program were required to complete a paper-pencil application. The application required contact information and other data used in this evaluation. Table 1 is an overview of program characteristics and makes comparison of the two projects.

Table 1.

Program Characteristics and Comparison of the Two Projects

Projects	PRIME (2009-10)	STAT (20010-11)
Grant Funding	$123,813	$174,106
Number of K-12 Districts	11	14
Number of Teachers	25	50
Participant Characteristics	19 elementary content; 3 middle school content; 3 special educ. Teachers	37 elementary content; 8 middle content; 5 special educ. Teachers
Name of Business Partners	1) Haddock Corporation; 2) Tri-County Technology Center; 3) Aurora Learning Community Association	1) Wizard Workshop; 2) Tulsa Air & Space Museum; 3) Aurora

		Learning Community Association 4) NASA
Partners' Role in Project	1) Technology Integration 2) Technology Pedagogy 3) Data-driven decision making	1) Technology Integration 2) Field Trip/Hands-on Museum - math contribution to aerospace industry 3) Data driven decision making 4) Mathematics inquiry based- aerospace examples
Higher Education Institute Partner	Northeastern State University & two NSU Mathematics Professors	2 NSU Mathematics Professors
Standards-based Focus	Geometry, Measurement & Fractions	Data Analysis & Probability

Assumptions

For this program and subsequent study, there were several assumptions. First, the higher education math content professors can assist teachers in improving their knowledge and teaching skills. Second, participants would commit to full participation in professional development activities. Next, project leaders and business partners were committed to success of program.

External Factors

Many of the program components identified were out of the control of the evaluator. For example, there was reports or data other than the self-reporting of the participant on the exposure and experience of technology use in classrooms, as well as the age and the number of teaching years of participants. There was no initial documentation on the willingness or reasons the teachers participated in the professional development. Factors involving previous teacher participant experience of professional development related to the content of this training was not considered. Lastly, the evaluator had no control on the university professors' delivery of content.

Summary

All project records were maintained in the OCIC office where the summer institutes were held. The lead LEA superintendent granted permission to access project records, including the enrollment applications. The applications contained data used in the evaluation study. Permission was by the Survey of Enacted Curriculum (SEC) Project Manager Research Specialist at the Wisconsin Center for Education Research, to access individual participant raw data taken from the SEC. A post-test was administered to participants following the projects. Participants were allowed to complete the post-test on-line or return the hard copy.

Chapter 4: Methods

Leaders who designed the professional development program hoped that teacher participants' reactions to the program would be positive, and teachers who took part in the mathematics program would consider it helpful and a valuable use of their time. In this section, the methods used to gather and analyze the evidence are explained. The intent of the evaluation was to determine if the desired outcomes of increased efficacy beliefs, better prepared teachers to teach mathematics, and improve mathematics content knowledge were observed.

Evaluation Design

This professional development program evaluation used a mixed method approach. Creswell (2007) identified mixed methods as analyzing research while incorporating "multi-method, integrated, hybrid, combined and mixed methodology" (p. 6). A similar definition of mixed methods is given by Johnson and Onwuegbuzie (2004); mixed methods is "the class or research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p. 17). Johnson and Christensen (2004) identify the benefits of using mixed methods by stating that "Research complements one set of results with another to expand a set of results, or to discover something that would have been missed if only a quantitative or qualitative approach had been used" (p. 18). This mixed method approach examined effectiveness by analyzing teacher performance on various proposed outcomes, including pre- and post-tests on teacher efficacy, mathematics pedagogy, and content knowledge measures. An analysis of answers to open-ended questions offered further evidence of teacher participant knowledge and skill gains.

Table 2.

Evaluation Questions and Data Collection

Evaluation Questions	Data Collection Tool	Stakeholder To Provide Data
1. Did teacher participants increase their efficacy for mathematics instruction?	Program Application (Pre-Test), On-line Researcher's Survey (Post-Test)	All Teacher Participants
2. Did teacher participants improve their instructional preparedness to teach mathematics content?	Survey of Enacted Curriculum (Pre- & Post-Test), On-line Researcher's Survey (Open-Ended Question)	All Teacher Participants
3. Did the mathematics content knowledge of teacher participants increase?	Pre- and Post-Test	All Teacher Participants

To understand if the mathematics projects worked for teachers, the researcher focused on:

1) general efficacy and technology efficacy
2) math instructional preparedness
3) math content knowledge

Measures

Efficacy

We know from research that efficacy enables teachers to be more open to new ideas and willing to experiment with new methods to better meet the needs of their students (Guskey, 1998). For this evaluation study, teacher's efficacy is defined as, "a belief of his or her capabilities to bring about desired outcomes of student engagement and learning (Bandura, 1977). Efficacy was measured using both a pre-post scale measure and an open-ended question. Two dimensions of math teaching efficacy were measured using scaled responses in both the pre- and post-test:

(1) scaled self-report of comfort in teaching math, and

(2) scaled self-report of comfort in using technology and manipulatives in math teaching

For the pre-post scale measure, the response items ask participants to answer using a scale from 0 (No Confidence) to 5 (High Confidence). This self-reported information is considered an effective way to collect the information of understanding the confidence level of teachers before and following the professional development program (Guskey, 2000). The items used for this measurement were taken from questions asked on the application participants completed to participate in the program and questions asked on a post survey sent out to participants following the program:

(1) Rate your confidence level in teaching mathematics content.

(2) Rate your confidence in using technology and manipulative in your math teaching.

The open-ended item was:

(1) Describe ways in which your instructional practice has changed because of your participation in Project PRIME/STAT.

This open-ended question pressed participants to extend their thinking beyond the content of the program's experiences, and asked participant to reflect on how learning was transferred back into the classroom. The researcher organized the reflective comments into groups, according to the participant's years of teaching experience, and looked for trends in learning, beliefs, and changes made in instructional practices.

Instructional Preparedness

Instructional preparedness for this evaluation study refers to how prepared the teacher participant is to teach the math content addressed in this professional development program. The Survey of Enacted Curriculum (SEC) was selected to measure teacher instructional preparedness to teach mathematics. This instrument was developed by Andrew Porter and John Smithson through the *The Council of Chief State School Officers* (CCSSO) at Wisconsin Center for Education Research (WCER). The SEC is a self-report instrument that is used to measure changes in instructional practice and instruction content in mathematics. In reviewing the literature on SEC, studies found the SEC to have 'acceptable internal consistency alpha reliability,' and 'good content predictive' validity evidence (Blank, Porter, & Smithson, 2001). The validity of SEC was determined by data collected from teachers in 123 classrooms of eleven states (60 science and 63 mathematics). Correlations were computed between student and teacher responses in order to determine degree of consistency between student and teacher reports. Class aggregated student data was used to determine validity, Among the 49 survey items used in mathematics classes, all but three items had significant and positive correlations that ranged from 0.20 to 0.74 (Blank, 2001).

The researcher selected six SEC items specifically related to mathematics. These questions measured mathematics instructional preparedness. The response set ranged from 0 (Not Well Prepared) to 5 (Very Well Prepared). The questions were:

How well are you prepared to:

(1) teach math at your assigned level?

(2) integrate math with other subjects?

(3) provide mathematics instruction that meets mathematic content standards (e.g. district, state, or national)?

(4) use a variety of assessment strategies (including objective and open-ended formats)?

(5) teach problem-solving strategies?

(6) teach mathematics with manipulatives, such as counting blocks or geometric shapes?

These SEC questions directly related to the professional development daily objectives, activities, and Oklahoma standards chosen for the two projects (Appendix A).

Content Knowledge Measurement

Content knowledge refers to math subject matter knowledge. The higher-education professors who led the instruction during the summer institute developed the content knowledge tests given to teacher participant pre-and post summer institute. The 20-item pre-and post-test used for each project in this study was designed to sample the courses as taught, and was based on common mathematics standards that was the focus of the profession development (see Appendix B and C). The test was scored using a 100-point scale and each question was worth the same number of points. No formal analysis of test reliability was conducted. The data from the pre- and post-test were used to gauge changes in mathematics knowledge following the professional development program.

Data Reduction and Analysis

For Quantitative data reduction, an Excel spreadsheet was used to organize the data for analysis. The column headings were:

- Participant identification number
- Teaching experience (years)
- Comfort in teaching math (efficacy) pre-test
- Comfort in teaching math (efficacy) post-test
- Comfort in technology use for math teaching (efficacy) pre-test
- Comfort in technology use for math teaching (efficacy) pre-test
- Teacher preparedness (self-report) pre-test (SEC)
- Teacher preparedness (self-report) post-test (SEC)
- Math content knowledge pretest
- Math content knowledge posttest
- PRIME participants
- STAT participants
- Participants that participated in both PRIME and STAT

The analysis compared pre- and post-test means for each of the three evaluation study questions. Bar graphs were used to display the comparison.

For a qualitative data reduction, responses from survey open-ended questions were grouped into teaching experience categories (i.e., novice, experienced, and veteran) in order to look for trends and themes of professional practice, belief, and understanding. The researcher highlighted words and phrases that best illustrated the trends or themes and helped answer the evaluation questions. While this approach to determining the effectiveness of the program is not the most persuasive, the preferred design of an experimental or quasi-experimental was not used in program. Therefore, the researcher is determining if the outcomes were achieved by judging an index of participants' professional knowledge base, what research says about the characteristics of high-quality professional development, teacher participants' self-reported increase in knowledge and skills and self-reported changes made in their classroom practices.

Summary and Limitations

Chapter 4 presented the methodology and procedures used to conduct the study. Both quantitative and qualitative data was gathered to analyze teacher performance on various proposed outcomes, including pre- and post-tests on teacher efficacy, mathematics pedagogy, and content knowledge measures. An analysis of answers to open-ended questions offered further evidence of teacher participant knowledge and skill gains.

Several limitations existed within the context of this study. First, within the time frame and the resources made available for this study, direct observation by this researcher of changes in classroom practice was not feasible. The researcher had only the composite scores from the professor-made pre- and post- assessments and was not able to analyze each teacher's test to identify, which specific content skills were mastered, and which were still missed. There were some data (i.e. required daily note cards reflecting teacher participant learning, frustrations, ideas, etc.) that would have been useful in capturing participant changes in thoughts about classroom instructional practices, but the note cards had no identifier to track participants. Another deterrent in getting a clear picture of all teacher participants is that not all teachers completed all of the surveys used in this study. Findings are based on the perceptions of teachers who did complete pre- and post-survey questions, and must be interpreted with this in mind. The size of the participant group was small and therefore tests of statistical significance were inappropriate. Chapter 5 provides the findings and analysis from the study including figures of the quantitative results and qualitative analysis.

Chapter 5: Findings

This section presents the qualitative and quantitative evidence related to the evaluation questions. The body of evidence is used to determine the degree to which the professional development achieved desired objectives of improved efficacy in teaching matter, improved instruction preparedness, and greater math knowledge. The chapter is organized by evaluation questions.

Question 1: Did teacher participants increase their efficacy for mathematics instruction? Both quantitative and qualitative evidence will be presented on efficacy beliefs of teachers who teach math, and efficacy beliefs for using technology and manipulatives with math instruction.

Quantitative Analysis: Efficacy In Teaching Mathematics Content

The content was different for each summer institute. The first institute, Project PRIME, included the content of geometry/measurement & fractions. Fourteen teachers provided both pre- and post- data. The second institute, Project STAT, covered the content of data analysis & probability. Twenty-eight teachers provided pre- and post- data. Eight teachers participated in both institutes. Along with a focus on mathematics standards and according to lesson plans, both institutes had a strong focus of incorporating technology and manipulatives in math instruction. The technology included interactive whiteboards and digital format to view ongoing, embedded and formative student assessment data. The manipulatives were such things as base 10 blocks, fraction bars, number sense lines, and geometric objects. Figure 3 shows pre-and post-measurements of mathematics content efficacy by each project, and for teachers who attended both summer institutes.

After an analysis of pre- and post-test performance, it was determined that participant confidence in teaching mathematics content increased during both projects. Figure 3 shows 56% of PRIME teacher participants reported on their confidence level in teaching mathematics content. The average program efficacy score was 3.5 and post program efficacy score was 4.4. For STAT, 56% of teacher participants reported. This group had the greatest increase in efficacy. The score of the average teacher participant prior to the summer institute was 2.8, and following the STAT summer institute, the score increased to 4.5. The eight teachers who participated in both projects had relatively the same increase in efficacy as the whole group of participants. PRIME started at 3.5 and increased to 4.6, and STAT began at 3.4 and increased to 4.5.

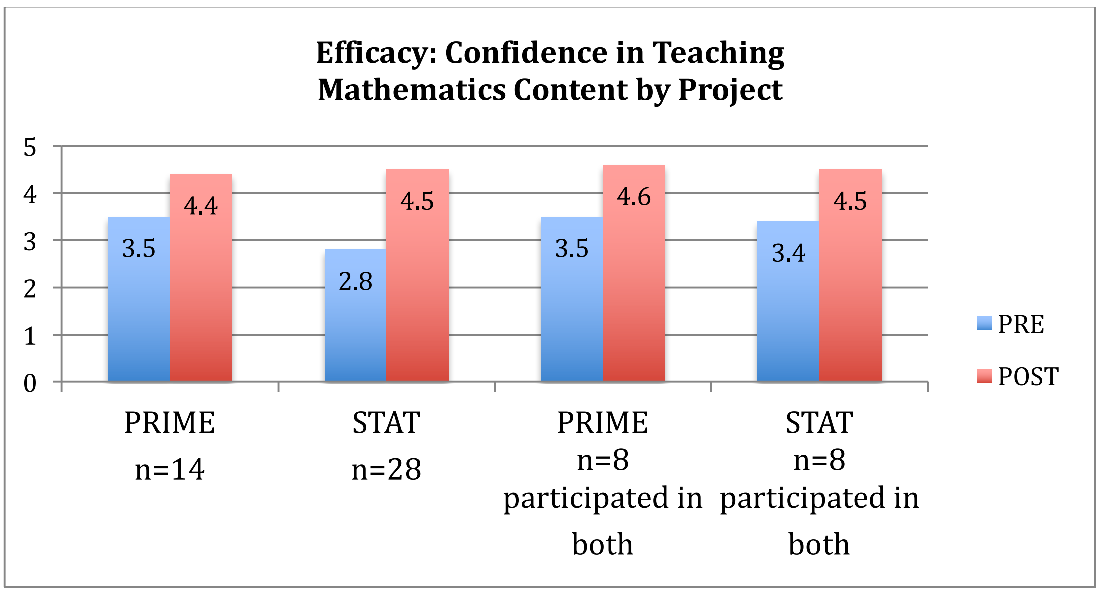

Figure 3. Bar Graph displaying a 5-point Likert Scale with a range of 0 'no confidence' to a 5 'high confidence' on the Vertical Axis. The Project Name and Number of Teacher Participants on the Horizontal Axis. The Value identified in each Bar is the Mean of Teacher Responses to the Item described at the top of the Graph.

Figure 4 further breaks down the same data as in Figure 3 by grouping teachers by years of experience. Teachers with five or fewer years teaching experience are referred to as novice teachers, and teachers with between six and fifteen years are named experienced teachers. Those teachers who have more than fifteen years of teaching experience are referred to as veteran teachers.

The chart shows the novice group entered both project summer institutes with the least amount of confidence in teaching the math content. PRIME novice teachers began the program at an average of 3 points on the efficacy scale of 0 to 5, and STAT at 1.7. This same group of teachers showed the most gain. PRIME efficacy for novice teachers increased by an average of two points to 5, and in STAT their average efficacy increased by 3 points to 4.7. Experienced teachers had an average efficacy score of 3.7 for Prime and 3.1 for STAT, and ended with 4.7 and 4.5 scores respectively. The veteran teachers had similar gains as that of experienced teachers. For PRIME, this veteran group started at 3.7 and ended at 4.2 and for STAT, began at 2.8 and ended at 4.5.

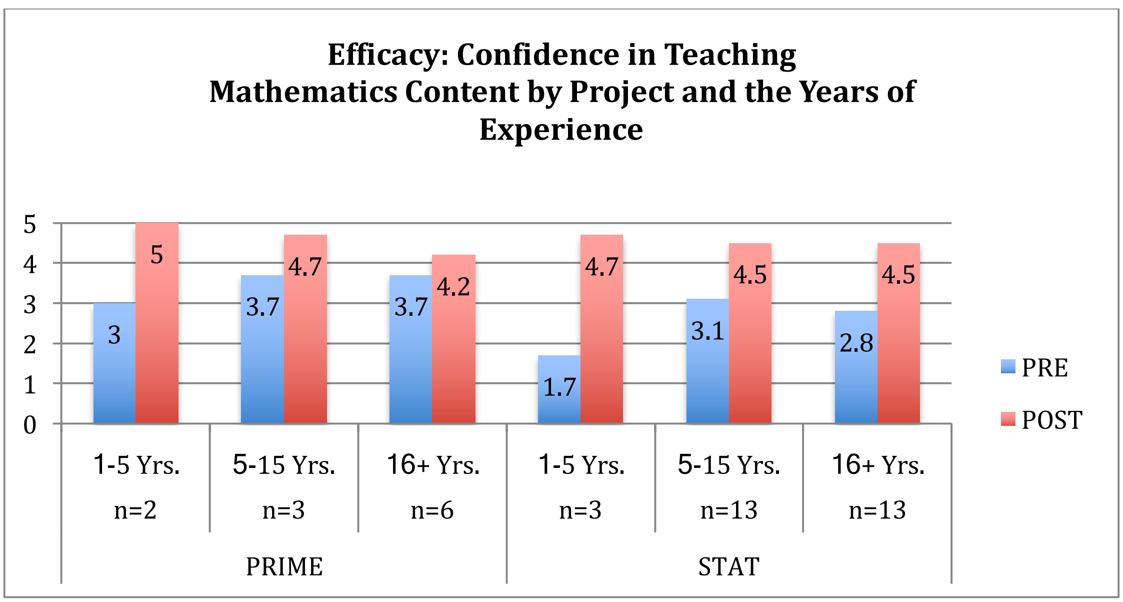

Figure 4. Bar Graph Displaying a 5-point Likert Scale on the Vertical Axis, and the Project Name along with Categories of years of Teaching Experience on the Horizontal Axis. The Value Identified in each Bar is the Mean of Teacher Responses to the Item described at the top of the Graph.

Qualitative Analysis: Efficacy In Teaching Mathematics Content Outcome

Teachers were asked whether the program helped improved efficacy in teaching mathematics. Appendix D provides the complete responses of participants. All teacher participants had overall positive comments about their comfort of teaching the standards addressed during the professional development. For example, teachers wrote:

- "I think the networking with other teachers and professors helped broaden the collective understanding of the subject matter. .... I know that my students will now have a better understanding of the concepts because of what I learned."
- "While I gained a deeper knowledge in content in mathematics, I felt that the content that I could actually take back to my students through hands-on applicable activities was the most useful to me."
- "I am now more confident in my content knowledge and better able to give my students immediate and helpful feedback when I'm teaching the skills I learned during the summer institute."

Next, the researcher was looking for responses that showed the teacher's learning drew on their own life experiences. There were only a few teacher responses the reflected this; one response was:

- "I have used more real-life situations in teaching probability, fractions, ..."

This response led researcher to believe there was professor-led instruction that allowed participants to link learning to past experiences of real-life situations. The researcher also looked for responses that supported the belief that participants were typically eager to learn and to further develop skills. This was evidenced by many teacher responses:

- "I have fallen in love with teaching math."
- "I have learned several ways of using hands-on activities that I hadn't ever used before."
- "These professional development opportunities have encouraged me to incorporate more data analysis, creation of charts and graphs, technology, and hands-on activities that have helped my students grow in their understanding and use of mathematics."

The researcher looked for responses that showed teacher participants were eager to immediately put knew learning to use in their classroom instruction. Again, there were several responses to support this assumption. Teachers wrote,

- "My math vocabulary increased greatly after attending Project STAT."
- I tried many of the them (referring to lesson plans) in my classroom and my students loved the hands-on approach."
- "Dr. Parrott always has great ideas that we can take to the classroom."
- "At the end of my program I had many new ideas to integrate into my lessons."

Lastly, the researcher looked for the support to know if the teachers were motivated to learn new instructional practices. Only one response mentioned they enrolled in the professional developed program for some other reason than to get more comfortable with teaching the math standards of covered in the program. This participant wrote she originally thought she would participate because of stipend she would receive, but her response states that her comfort in teaching statistics and probability greatly increased by the end of the program.

Along with examining teacher participants responses with adult learning theory assumptions, the researcher grouped the responses in relationship to the number of teaching years' experience to look for trends of learning. Findings from this sub grouping showed the responses of less experienced teachers focused solely on what the professional development did for the teacher as the learner, and the response of the more experienced teachers focused on what the professional development experience meant for the teacher based on how well their students did as the learner. Examples of responses to support this finding is:

- Novice Teacher – "I learned a lot more ways to teach geometry and fractions."
- Experienced Teacher – "I felt much more comfortable and knowledgeable in the content."
- Veteran Teacher – "I used what I learned to help my students learn math"; "Students really seem to have a good grasp of the concept"; and, "I have changed the way I allow students to find their way of finding the answers."

Looking at other trends of successful gains in efficacy, there were several teachers that wrote that the networking with other teachers with whom they shared the professional development experience helped them feel more comfortable with increasing content knowledge. For example, one teacher wrote,

- "I think the networking with other teachers and professors helped broaden the collective understanding of the subject matter."

Quantitative Analysis: Comfort In Using Technology and Manipulatives

The second efficacy measurement looked at how comfortable participants were using technology and manipulatives in their math teaching. Using technology was an integral component of both projects. Figures 5 and 6 show teacher participants' change in confidence for using technology tools as well as the manipulatives demonstrated in the professional development program. The results show the average of teacher participants as a whole group (Figure 5), and then by years of experience (Figure 6).

Figure 5 shows the average teacher participant score on their comfort in technology and manipulatives use for math teaching was 3.1 before the professional development and ended at 3.9. These data were not disaggregated by project because the same sort of technology and manipulatives were used in both summer institutes. For the eleven teachers who participated in both summer institutes, their pre-score of 3.0 was taken at the beginning of PRIME and their post-score of 3.9 was from the end of STAT. The eleven teachers ended with the same post-score of 3.9.

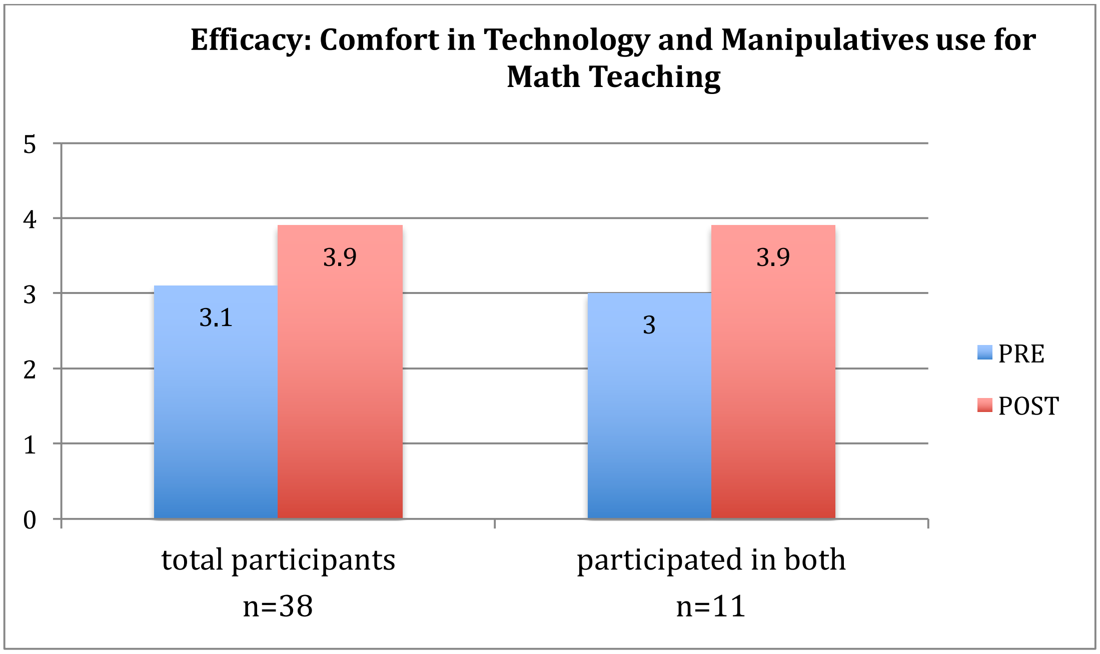

Figure 5. Bar Graph Displaying a 5-point Likert Scale on the Vertical Axis, and the Number of Teacher Participants on the Horizontal Axis. The Value Identified in each Bar is the mean scale score of participants.

Figure 6 shows overall, no matter the years of teaching experience, participants began the professional development program show at least some confidence in their preparedness to integrate technology and use manipulatives in their mathematics instructional practice. The novice group and the veteran group began the program with the same average efficacy score of 2.8. The experienced group of teachers began at a slightly higher efficacy score of 3.6. All three groups made gains. The novice group ending with 4.0 made a 1.2 gain, and the experienced teachers had a .6 gain, ending with 4.2. The veteran teachers ended with 3.7, which was a 0.9 gain. Because the novice teachers typically have more expertise using technology, the researcher first guessed this group of teachers would have scored the highest level of efficacy in the beginning. The researcher feels that although this novice group of teachers grew up using more technology compared to the other two groups, the novice teachers were not students of teachers who modeled math instruction using technology and manipulatives. Therefore, it makes sense this group of teachers was not more comfortable using technology and manipulatives in their own math instruction than that of the other two groups.

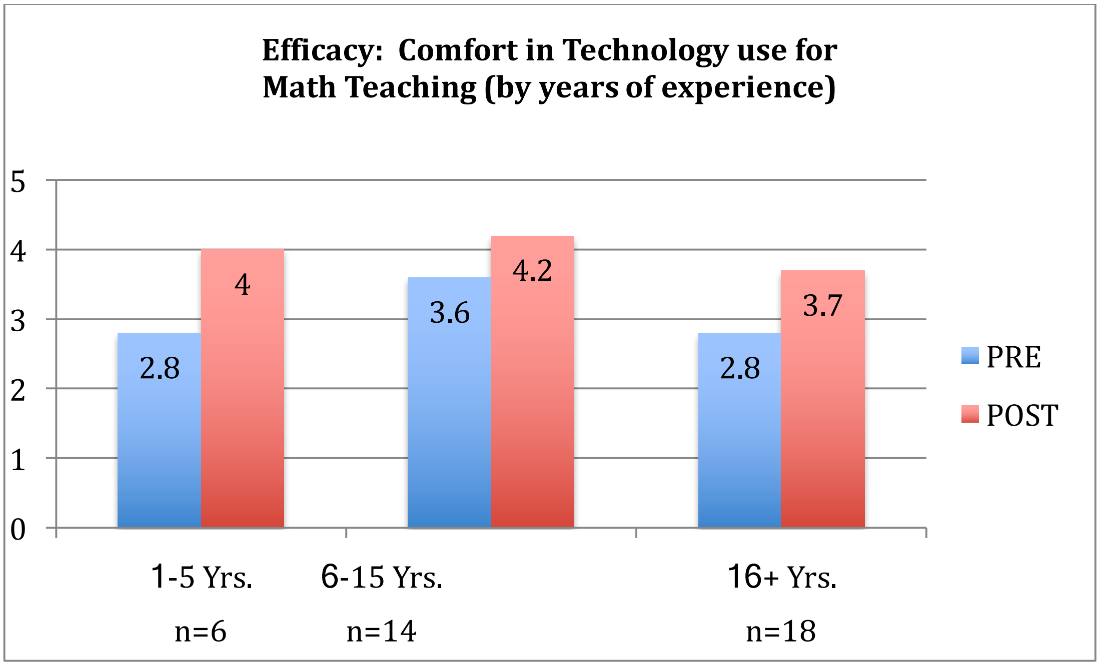

Figure 6. Bar Graph Displaying a 5-point Likert Scale on the Vertical Axis, and the Project Number of Teacher Participants and Categories of years of Teaching Experience on the Horizontal Axis. The Scale Value Identified in each Bar is the Mean of Teacher Responses to the Item described at the top of the Graph.

Qualitative Analysis: Comfort in using Technology and Manipulatives

Teachers were asked whether the program helped increase their preparedness in using technology and manipulatives in their math instruction. Responses of participants are provided in Appendix E, and are grouped into three sections based on years of teaching experience. Consistent with the earlier observation, the researcher noted that veteran teacher comments focused on how much improvement was made by their students' learning rather than the changes in instruction made in their classroom practice.

Although the majority of teacher responses led the researcher to believe they were comfortable with using technology (i.e., “I have been able to engage my students in various hands-on mathematics/science related activities”), there were a few comments suggest that not all teachers believed they gained the tools to make these changes in the instructional practice (i.e., “Still technophobic”).

Although the quantitative data in which teachers responded to items asking them about their comfort using the technologies showed an increase in overall efficacy, there were individual teacher responses that led the researcher to think that some teacher participants may not have had substantial change in their efficacy with using technology. For the most part, the written expressions about the use of technologies and manipulatives when teaching mathematics provides substantial insight that the majority of teachers were prepared to integrate the technologies and manipulative into their instruction. One teacher responded, “Technology has even changed the way I do assessments in my classroom.” Another said, “I also learned a few new things in the technology department where I can use all the help I can get.”

Question 2: Did teacher participants improve their instructional preparedness to teach mathematics content?

Both quantitative and qualitative evidence will be presented to understand if instructional preparedness improved. Figure 7 show findings for improved instructional preparedness taken from the program application (Pre-Test), and the on-line researcher’s survey (Post-Test). The Likert-scale used to record responses ranged from 0 (not well prepared), 1 (somewhat prepared), 2 (well prepared), to 3 (very well prepared).

Quantitative Analysis: Instructional Preparedness

The average pre-test score for each project and for the participants who participated in both projects fell slightly below the well-prepared category. Figure 6 displays the median scores taken from the survey questions on the applications and follow-up survey. For PRIME, the beginning score was 1.4 and ended with 1.7, and STAT had a beginning average of 1.5 and ended with 1.7. There was little gain from any of the three sub groups. The thirteen teachers who participated in both projects made the most gain starting with 1.3 and ended with 1.8.

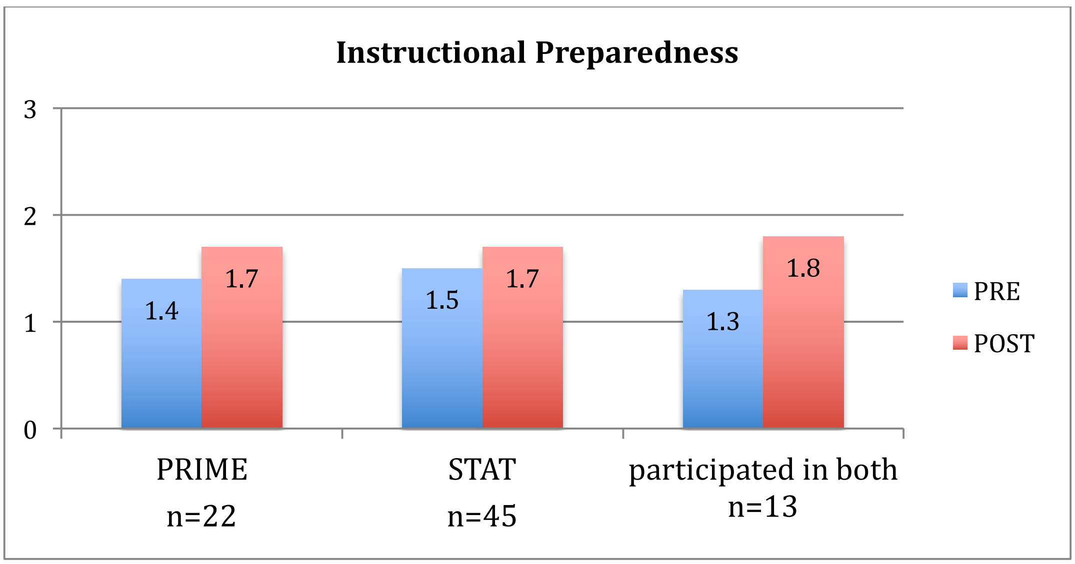

Figure 7. Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name and Number of Teacher Participants on the Horizontal Axis. The Value Identified in each Bar is the Mean of Teacher Responses to the Total Combined Score of the SEC six items asked on the Survey.

Figures 8-13 show further findings of teacher perceived instructional preparedness taken from the Survey of Enacted Curriculum. The Likert-scale used to record responses ranged from 0 (not well prepared), 1 (somewhat prepared), 2 (well prepared), to 3 (very well prepared). On the bar graphs, the vertical axis displays a Likert scale. The horizontal axis identifies the two projects, and the bars within the graph contain the mean score of participants disaggregated by years of teaching experience. The values of the scale begin at zero, not at all prepared, and continue by half point increments to three, highly prepared.

Figure 8 shows evidence of pre- and post- scores indicating how well-prepared teachers were to teach math at their assigned level. For PRIME, the teacher participants began the project with an average score of 2.2 and ended with 2.4. Analysis showed in the beginning of the project, the experienced teachers felt they were less prepared to teach math at their assigned grade level than the novice and veteran teachers, but ended the project making the most gain in instructional preparedness. The novice began at 2.2 and ended with 2.4. The veteran teachers started with the highest median score of 2.4 and ended at the same of 2.4. The experienced teachers began at 1.8, and with a 0.6 increase, and ended at 2.5.

For STAT, the teacher participant began the project with an average score of 2.3 and ended with 2.5. Novice teachers began the project feeling the most prepared to teach math at an average 2.6 score, and ended the project with a 2.0 decline, scoring 2.4. Experienced teachers began at 2.3 and ended with a mean value of 2.6, and veteran teachers started with 2.2 and ended with a mean value of 2.5.

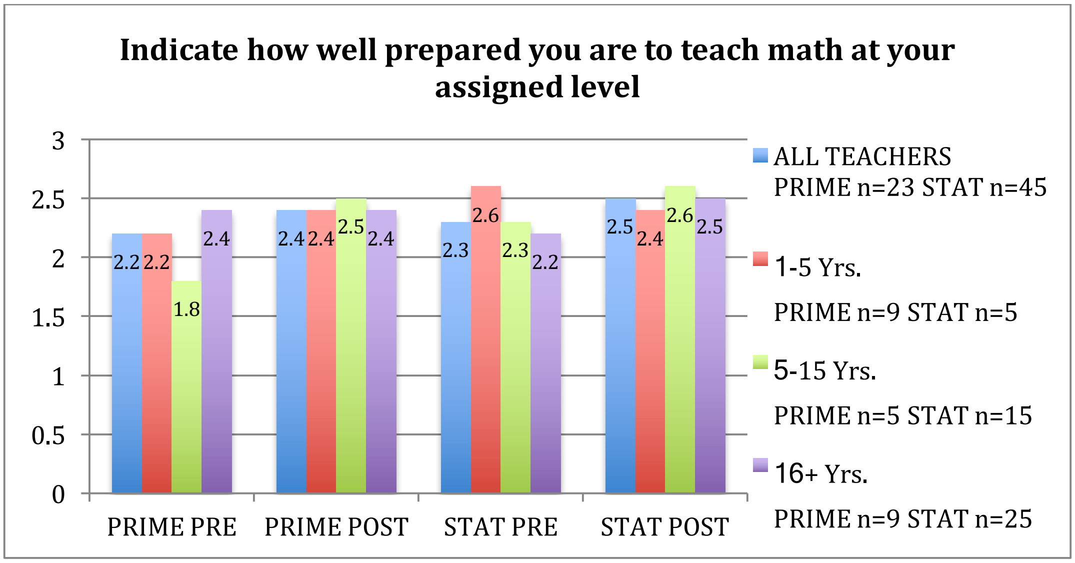

Figure 8. SEC Item 1: Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name on the Horizontal Axis. The value within each bar is the mean of teacher responses to the item listed at the top of graph.

Figure 9 shows evidence of how well teachers were prepared to integrate math with other subjects. PRIME began with a 1.6 mean value score and increased to a 1.8 post-test score. Novice teachers began the program with the highest mean value at 1.8 but made only a slight increase ending at 1.9. Experienced teachers started out with a 1.5 mean value and increased to a 2.0. Veteran teachers began at 1.4 and made the most gains ending with a 2.4 mean value score.

STAT began the program with a 1.7 mean value and ended with the same score. Novice teachers started with the highest mean value of 2.2, but decreased to 1.4. Experienced teachers began at 1.6 and made the most gains ending at 2.4. The veteran teachers showed no changes beginning at a 1.7 and ended at 1.7.

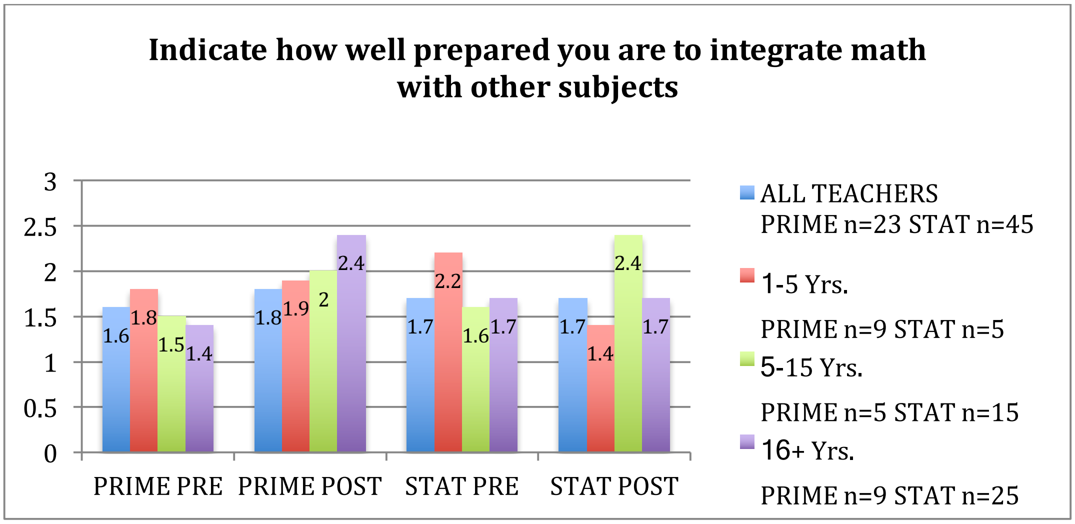

Figure 9. SEC Item 2: Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name on the Horizontal Axis. The value within each bar is the mean of teacher responses to the item listed at the top of graph.

Figure 10 shows how teachers felt about being prepared to provide math instruction that meets content standards following both projects. PRIME teachers began the project at a mean value of 2.0 and ended at 2.3. Novice teachers started at 2.1 and ended at 2.2. Experienced teachers started at 1.8 and ended at 2.8. The veteran teachers started out with 2.0 and ended with highest score of 2.4. The veteran teachers began at 2.0 and increased to 2.9.

STAT had the same beginning and ending score of 1.7. The novice teachers had the same pre- and post- score of 2.4, The Experienced teachers began at 2.3 and made a small increase to 2.6. The veteran teachers made the most gain as they started the program at 2.2 and post score was a 2.6.

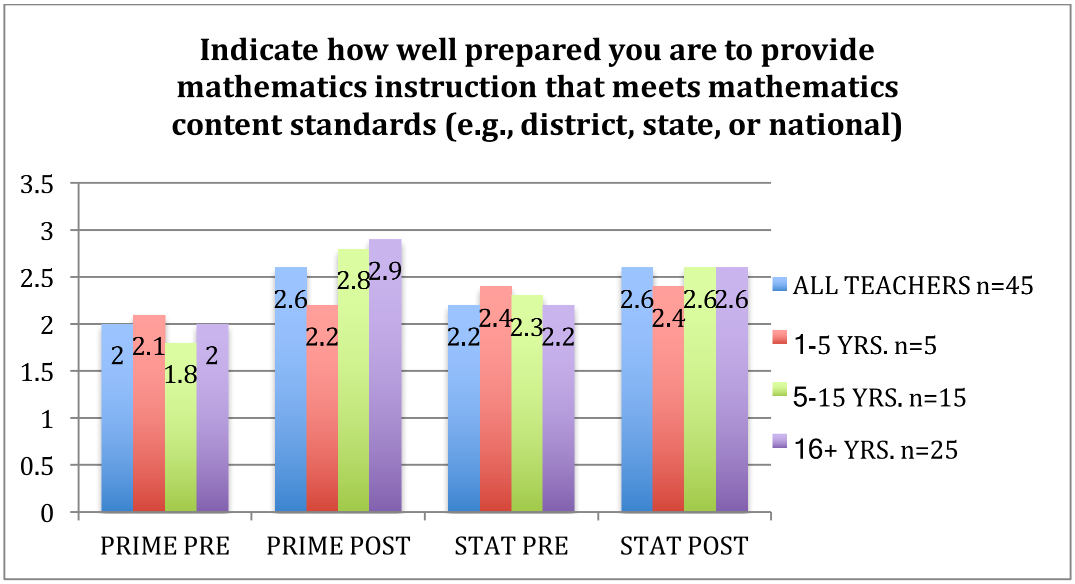

Figure 10. SEC Item 3: Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name on the Horizontal Axis. The value within each bar is the mean of teacher responses to the item listed at the top of graph.

In Figure 11, teacher participants were asked about preparedness for using a variety of assessment strategies. A review of the summer institutes' objectives listed assessment strategies were to be covered in both project trainings. As viewed in Figure 10, the group of all teachers began PRIME with a mean value of 1.2 on the scale and increased to 1.7. In PRIME, the novice teachers began with 1.7 and ended with 1.9. The experienced teachers began at 1.0 and ended with a 1.3. The veteran teachers started at the lowest score of 0.7, but made the most increase and had the highest score in the end at 2.3. For STAT, the group of novice teachers began with 1.6 but had a decrease value to only 1.0. For the experienced teachers, there was little change between pre-and post values for both projects. This group started at a 1.3 and ended with a 1.5. The veteran teachers started at 1.3 and ended at 1.7.

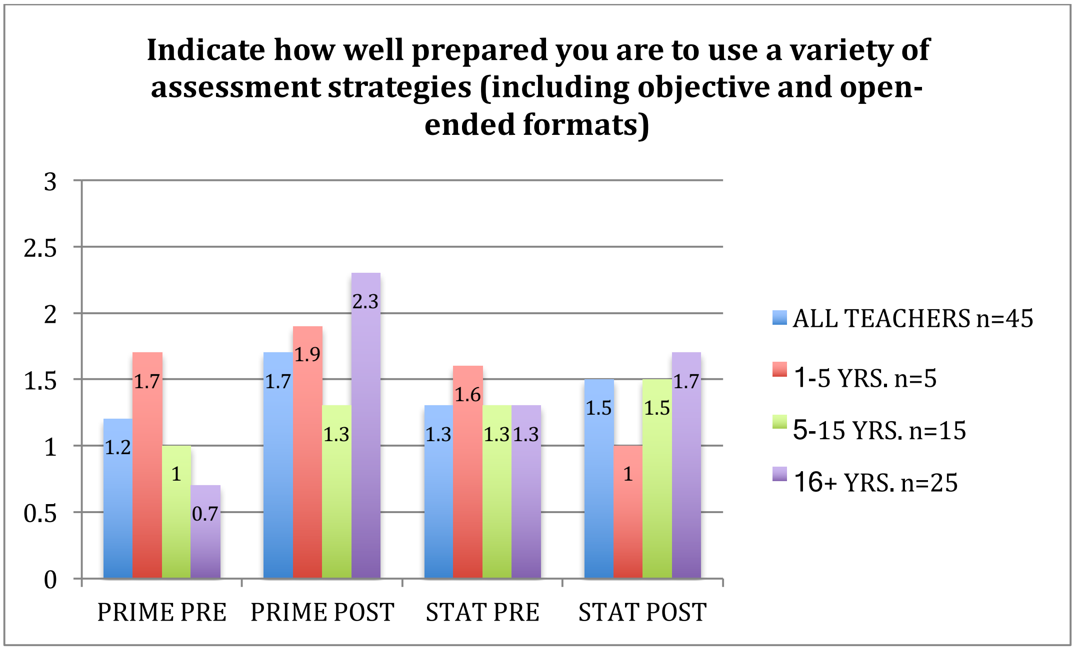

Figure 11. SEC Item 4: Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name on the Horizontal Axis. The value within each bar is the mean of teacher responses to the item listed at the top of graph.

In Figure 12, the median pre- and post- scores indicate how well prepared the teacher felt she was to teach problem solving strategies. For PRIME, the group of teachers began with a 1.6 and increased to a 1.9 by the end of the project. The novice teachers started out with an average score of 2.0. They made a slight increase to 2.2. The experienced teachers also began at 2.0 but ended the program with the same score of 2.0. The veteran teachers started out at a low of 1.1 and ended with 1.6. In STAT, the group started out with 1.7 and increased to 2.0. The novice teachers began at 1.8 and ended with the same score of 1.8. The experienced teachers began at 1.9 and also ended with no change at 1.9. The veteran teachers started at 1.6 and increased slightly to 1.9.

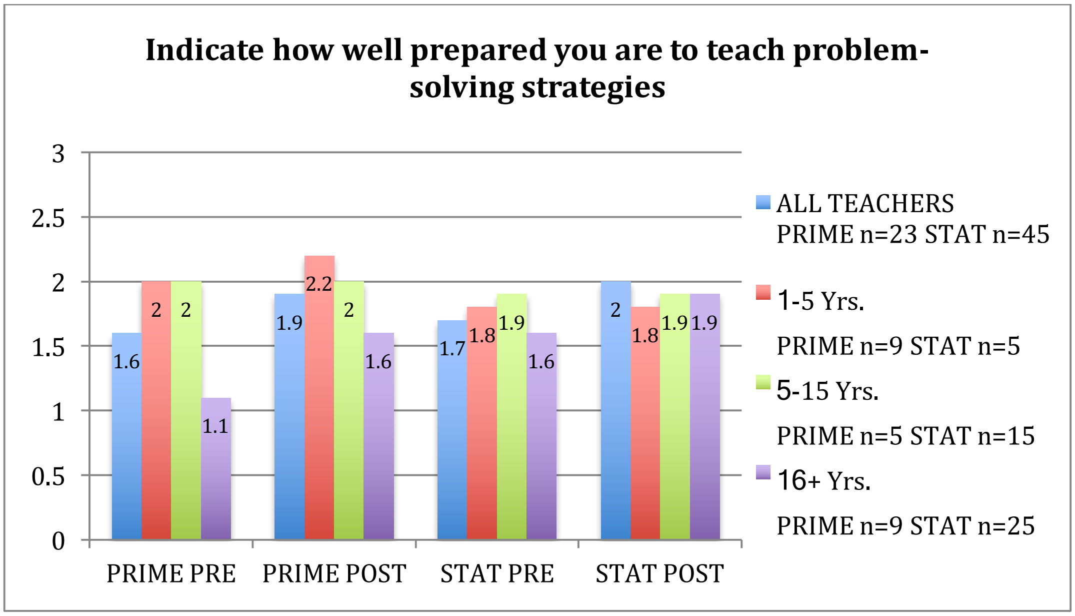

Figure 12. SEC Item 5: Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name on the Horizontal Axis. The value within each bar is the mean of teacher responses to the item listed at the top of graph.

Figure 13 shows how the teachers perceive their preparedness for using manipulatives to teach mathematics. For PRIME, the group of teachers began at an average of 1.6 score and their post-test score was 1.9. The novice and experienced teachers both scored a 2.0 on the pre-test, and although the novice increased to 2.2, the experienced teachers' post-test score remained at 2.0. The veteran teacher started out with a low score of 1.1, but increased to a 1.6 on the post-test score. STAT teachers started at a 1.9 and ended at a 2.1. The novice teachers began the problem feeling more prepared than the other two groups scoring a 2.4, but their ending score decreased to a 2.0. The experienced group had a 1.7 pre-test score and a 2.2 score in the end. The veteran teachers had a 1.9 pre-test score and a 2.1 post-test score.

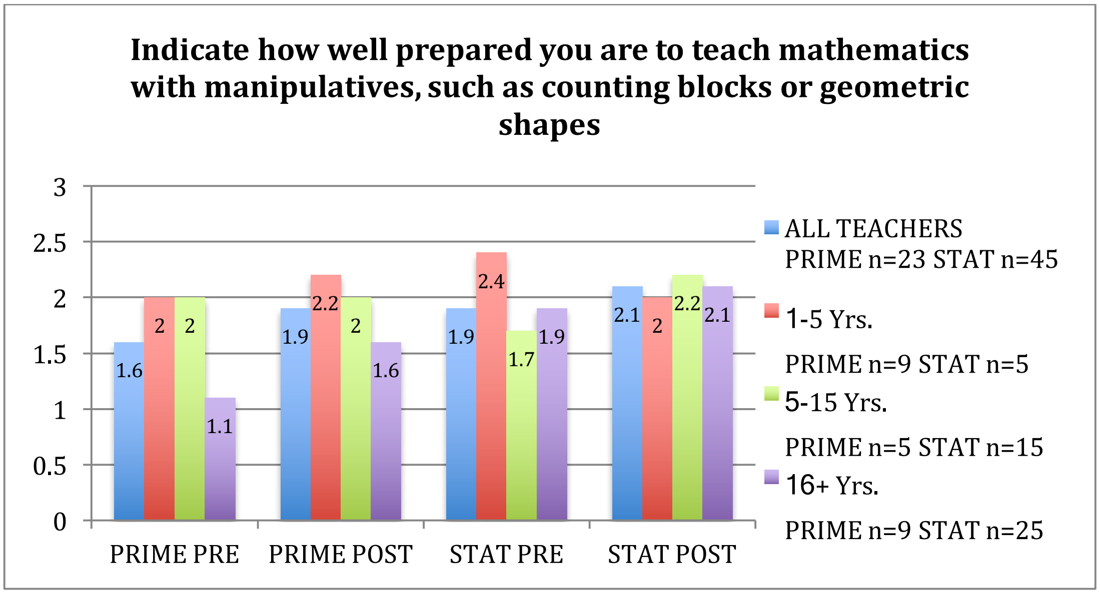

Figure 13. SEC Item 6: Bar Graph Displaying a 3-point Likert Scale on the Vertical Axis, and the Project Name on the Horizontal Axis. The value within each bar is the mean of teacher responses to the item listed at the top of graph.

Qualitative Analysis: Instructional Preparedness

The researcher examined responses to survey questions to determine further evidence of gains and decreases made during the professional development program in instructional preparedness. Examples of responses included:

- "I feel better prepared to teach my students and feel more confident in my explanations to them about the content."
- "I've learned many ways to make learning the objective more hands-on instead of just giving my students problems out of a book."
- "I walked away with many lessons and lesson plans that incorporated technology."
- "I have also been able to more closely relate and integrate math and science in my lessons."

- "I feel much more prepared and capable after seeing actual teaching modeled at the training."
- "I feel better prepared to teach my students...."
- "I feel more comfortable teaching these concepts."

Teachers made comments they were better prepared to teach the math content because of their desire to gain math knowledge to be better teachers. One teacher related her learning to better understanding of the grade level skills she taught, but noted she still did not fully understand some of the skills. Another teacher's response made researcher think she did not obtain intended instructional preparedness training. She wrote, "We learned things I will not use."

Question 3: Did the mathematics content knowledge of the participants increase?

Quantitative Analysis: Increase Content Knowledge

Summarizing a number of research studies, there is evidence that teacher's content knowledge influences how he or she engages students in the subject matter, and what resource materials are used by the teacher. (Cochran, DeRuiter, & King, 1993; Fernádez-Balboa & Stiehl, 1995; Grossman, 1990; Loucks-Horsley, et al.; 2010; Loughran Mulhall, & Berry, 2004). Teachers were given a professor-made test on the first day of the summer institute, and again on the final day. The multiple-choice tests can be viewed in Appendix B and C. The tests were scored using a percentage correct. The problems on the tests were directly related to the standards covered during each project's content (i.e., PRIME - geometry/measurement & fractions; STAT - data analysis & probability).

The results from the pre- and post-test in the content areas of each project revealed that all teachers increased their content knowledge. Figure 14 shows a mean score of the participants for the pre-test on both projects was below 50%. No teacher scored 100% on the pre-test of either project. PRIME's average score on the pre-test was 47% and the post-test was 73%. STAT's average score on the pre-test was 45% and the post-test was 82%. The teachers participating in both projects had similar scores as those of the entire group of teachers. These thirteen teachers on PRIME had a median pre-test score of 45% and a post-test score of 72%. On STAT, these same teachers' pre-test average score was 46% and their post-test was 84%.

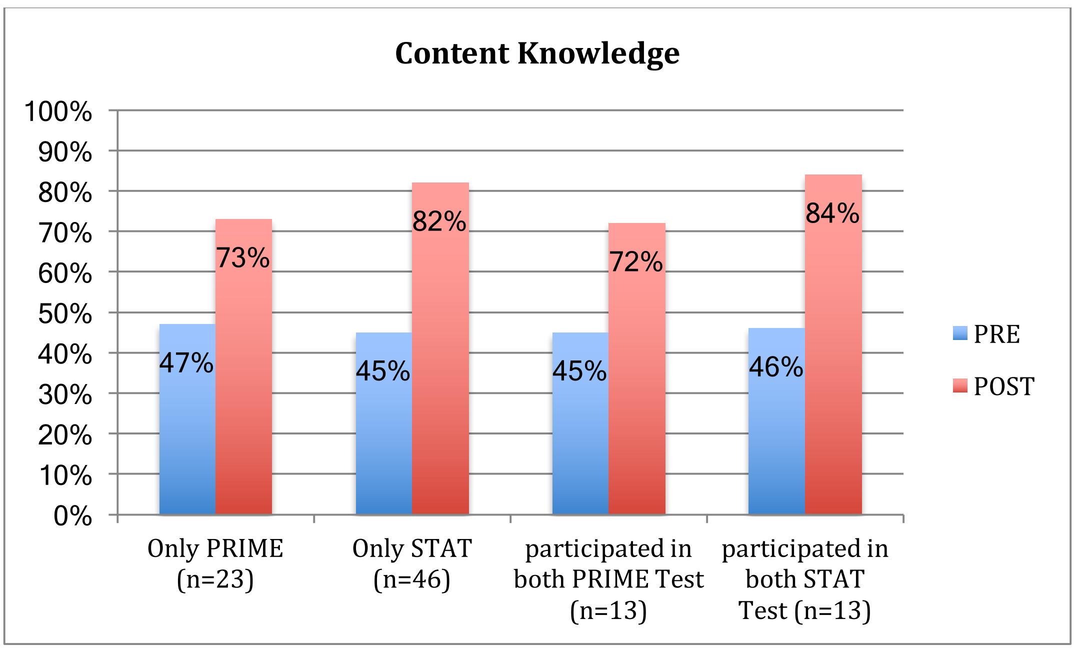

Figure 14. The Vertical Axis on the above Bar Graph shows the Percentile of correct answers on the pre- and post assessment. The horizontal axis provides the project name and the number of Teacher Participants. The value in the bar represented the mean score for the total number of Participants.

Figure 15 shows the amount of content knowledge increase made by each group of teachers by number of years of experience. The pre-test scores for the three categories of years of experience, beginning with novice, then experienced and ending with veteran (56%, 48% 43% for PRIME and 44%, 33%, 39% for STAT) showed all three groups were relatively similar, as were the post-test scores (76%, 77%, 80% for PRIME and 99%, 90%, 92% for STAT).

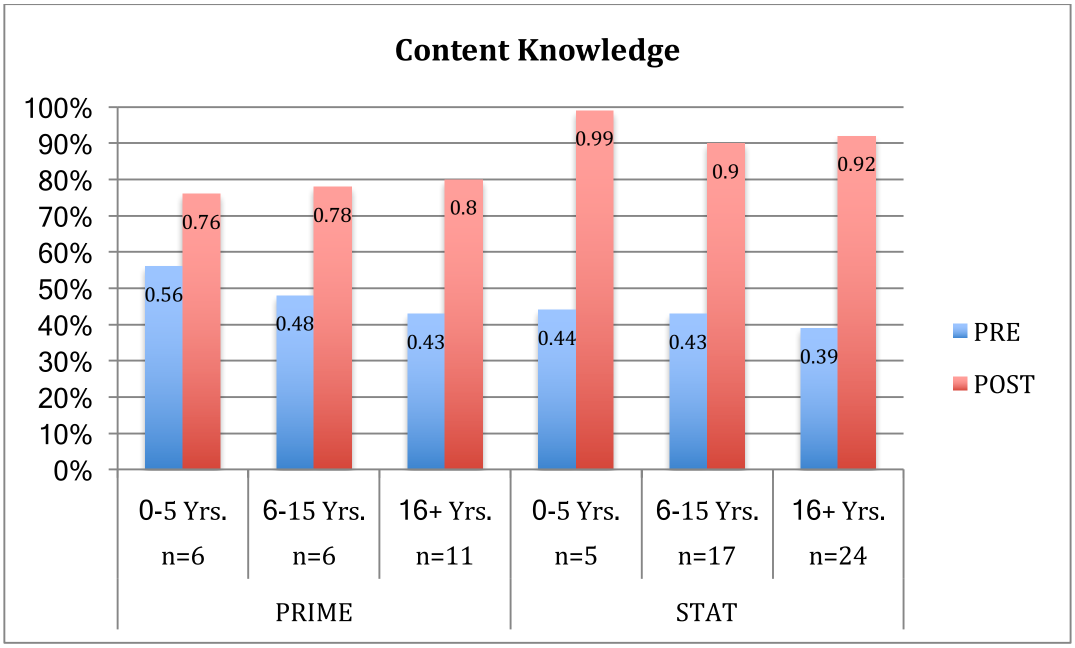

Figure 15. The Vertical Axis on the above Bar Graph shows the percentile of correct answers on the pre- and post- assessment. The horizontal axis provides the project name and the number of teacher participants further broken down into Categories of Years of Experience.

Qualitative Analysis: Increase Content Knowledge

The project director, which was the same person for both projects, shared with the researcher that many of the teacher participants were hesitant to enroll in the professional development program because they knew they would be required take a test to measure their pre- and post- math content knowledge. The lesson plans identified activities that were all linked to increasing the mathematics content knowledge. There were no responses related to teachers taking the pre-and post- test, and few responses related to the outcome of increasing content knowledge. Some of the responses were:

- "I gained a deeper knowledge in content in mathematics."
- "My knowledge of the subject matter increased."
- "Each time I mastered a skill, it gave me more knowledge and confidence."

The final chapter further explains the analysis and discussion of data. It also ends with recommendations for future professional development.

Chapter 6: Discussion

The purpose of this study was to evaluate a mathematics professional development program to determine if the outcomes of increased efficacy for math instruction, instructional preparedness, and increased math content knowledge were observed. The findings from this study indicate that, following the professional development program: (a) there was overall increased teacher efficacy for math instruction along with the use of technology and manipulatives; (b) most teachers believed they were better prepared to teach math content; and, (c) all teachers increased their mathematic content knowledge.

Efficacy

For research question one, “Did teacher participants increase their efficacy for mathematics instruction?” an analysis of the data revealed that the average teacher participant reported an increase in their math-teaching efficacy. Teacher perceptions of their efficacy of math content instruction and the use of manipulatives and technology were analyzed.

Math content. All three sub-groups of teachers (novice, experience, veteran) increased in their confidence to teach. In both projects, the novice group of teachers had an average pre-score lower than the experienced and veteran groups of teachers. Prior evidence suggests critical distinctions between those with few years of experience as opposed to more experienced teachers (Berliner, 1994). Experienced and veteran teachers have developed stable practices that may make change harder, while novice teachers may have an easier time with observation and taking in the modeling process (Bandura, 1977). The fact that sub-groups all ended both projects with similar scores, provides some justification for assuming that novice teachers did in fact relate positively to the social context of the learning processes. Because Bandura's theory of self-efficacy suggests that efficacy may be most malleable early in learning, and this study suggest novice teachers did improve self-efficacy in their math instruction, it is likely these teachers will continue long-term development of teacher efficacy.

To better understand how this program led teachers to increase their math teaching, the researcher paid attention to the contextual and environmental factors of the program. Teachers frequently mentioned positively the opportunity to work together. Many of the participating schools have only one math teacher at each grade level. By bringing these rural schools together, teachers work together, as well as discuss concepts, skills, and problems that arise during their professional development experiences. Many respondents referenced the opportunities to share resources and interact with colleagues who have similar responsibilities in other schools, as well as observe professor instructors in modeling strategies to improve math content knowledge.

In general, the evidence from this report suggests that teachers enrolled in the program became better math teachers. Bandura notes that when teachers' work together on shared beliefs about their capabilities, and there is an environment and social system in place to support efficacy attainment, it is likely to influence the behavior of the teacher in a positive way (Bandura, 1986, p. 25). Knowles asserts that teachers are motivated to learn when there is a need to know. In this study, only one teacher indicated that she enrolled in the program for the stipend. Later, this same teacher described the positive learning experience she had in the program. Many respondents based their level of learning from the professional development on how well their students understood the math concepts they taught.

Manipulatives and technology. Teachers claimed to increase their efficacy in the use of manipulatives and technology within their mathematics instruction. The professional math educators' lesson plans (Appendix A), and responses of teacher participants, document active learning in every lesson. The program promoted modeling and practice time with new teaching strategies. Teacher participants were provided an environment where they could practice the use of technology and using manipulatives in a safe demonstration environment, thus enhancing their efficacy. There is evidence that teachers with strong positive efficacy beliefs about their teaching ability are more likely to take risks and use new techniques, and to experiment and persist with challenging strategies that may have a positive effect on student achievement (Guskey, 1988). Teachers may not have the knowledge about all of the technical tools available, but, having strong teaching self-efficacy with technology and experience using manipulatives are more likely continue this practice after the professional development program ends (Mueller, Willoughby, Ross, & Specht, 2008). On the other hand, Bandura's claims about the importance of self-efficacy beliefs in explaining behavior led the researcher to believe that it is possible that those few teachers who responded negatively about using the technology introduced did not try the newly learned technologies or manipulatives in their classroom.

Math Preparedness

For research question two, "Did teacher participants improve their instructional preparedness to teach mathematics content?" the collective findings for the outcome of teacher preparedness showed for the most part, teachers did believe the professional development program increased their preparedness to teach mathematics. There were low pre-program beliefs about math preparedness for both the PRIME and STAT projects. The post-test of teachers participating in both projects revealed math preparedness gains although they were small. To better understand why these gains were small, the researcher looked closely at data for different areas of teacher preparedness: teach math at assigned level; integrate math with other subjects; meet mathematics content standards; use a variety of assessment strategies; teach problem solving strategies; and, teach mathematics with manipulatives.

Teach math at assigned level. Self-reports showed that most teachers at the beginning of each summer institute believed they were well prepared to teach math at their assigned grade level. It was surprising to see such high pre-program values here since the content for the summer institutes (geometry/measurement, fractions, data analysis, and probability) was chosen because the districts' student state tests scores were low. The post-program beliefs showed some gain in teachers' preparedness to teach at grade level, and teacher scores fell between well prepared and very well prepared on the scale used.

Integrate math with other subjects. Coming into the program, teachers in both projects did not feel they were very prepared to integrate math with other subjects. All groups (novice, experienced, veteran) in the PRIME project showed an increase in their belief to integrate math with other subjects. It is speculated that there were activities in PRIME involving the integration of math with other subjects, since one teacher response indicated she was excited to learn of ways to incorporate math into her science lessons. For the STAT project, the novice teachers' scores decreased, and the experienced and veteran groups made no change. There was little evidence of this type of activities included in the STAT lesson plans.

Meet mathematics content standards. Summer institutes focused on math content were included in both projects. Professional math educators' lesson plans revealed that the activities of the summer institutes were aligned to what students are expected to learn, and how students learn subject matter. This is consistent with Bandura's claim that we can learn primarily from observing others. Several participant responses suggest that their preparedness beliefs were increased after watching the professors' model teaching of the content. With the alignment of professional development activities with data analysis and state standards, it also helps ensure that instructional improvements are sustained (Youngs, 2001). Data revealed participants stated after the professional development they were better prepared to develop lesson plans and teach the math content.

Use a variety of assessment strategies. There were many opportunities during this professional development program for teachers to collaborate with each other and with university experts. Each summer institute included over 70 hours of professional development. Helping teachers become aware of the need to have mathematic content knowledge was vital to teachers investing in their own learning (Ball & Bass, 2005). Having a depth of mathematics knowledge better supports teachers with pedagogical skills to teach the content and use a variety of assessment strategies to measure student learning (Desimone, 2009). The evidence from this study shows that this program did help teachers feel better prepared to use a variety of assessment strategies when they returned to their classrooms. Additionally, the business partners provided opportunity for teachers to test their new learning in real-world application. Taking these learning experiences back to their own classrooms will help them realize the importance of using experiences in their instructional practice and assessment measures.

Teach problem solving strategies. The novice and experienced groups made only small gains or no gains in their perceptions of how prepared they were to teach problem solving. There was no obvious explanation for these results. The project director explained that experienced teachers infrequently used problem-solving math (i.e. word problems), believing it was for advanced students only. Knowles' assertion that teacher learning depends a lot on relevance of the topic could be why there were only small or no gains made (Knowles, 1984).

Use of manipulatives. Teachers for the most part did feel that PRIME and STAT better prepared them to teach the content with the use of manipulatives. PRIME participants upon entry into the program had an average teacher score that showed they did not feel they were prepared to use manipulatives such as counting blocks or geometric shapes. Interestingly, it was veteran teachers who brought the average score down. It is possible this group of teachers, which was more than half of the participants, had never used manipulatives with math instruction. For the STAT group, there was a very high pre-score for novice teachers. This group of young teachers felt they were prepared to use manipulatives in their teaching of statistics and problem solving. The optimism of this group of teachers may have been somewhat tarnished when confronted with the complexities of the statistical and problem-solving teaching task because their post score decreased, but did not fall below the score of feeling prepared. Again, the modeling from math professors using manipulatives, and teacher access to these resources following the professional development program my help sustain teacher preparedness.

In summarizing teacher preparedness, most teacher participants ended the program with score values showing they believed they improved their preparedness to teach the mathematics content. There is evidence that teacher knowledge of the subject they teach, and knowledge and skill in how to teach, is critically important in teacher preparation. Although there was only a small amount of improvement perceived by teacher participants in their preparedness to teach math content and use technology and manipulative tools, even small gains in teacher preparedness is an important component to building a stronger professional learning community in the schools they serve (Guskey, 1988).

Content Knowledge

"Did the mathematics content knowledge of the participants increase?" is the third question addressed in this study. Since content experts taught the two summer institutes, and developed the assessment used in the program, it was expected that teachers would improve their test scores. Based on this evaluation, the professional development program did lead to significant gains in every teacher participants' mathematical knowledge.

Discussion Summary

This evaluation provided evidence of how teacher instructional practice and efficacy were affected by the activities presented in the professional development program. As a result of the study, more is known about the conditions needed for these elementary teachers who work in rural public schools to apply their professional development learning to their practice. Relying on Knowles' claims about how teachers learn best, and understanding the importance of Bandura's triadic interaction of behavior, personal, and environmental factors that influence behavioral change, several features are suggested to enhance self-efficacy, outcome expectations, and reinforcements that would increase the chance that positive changes would continue in the classroom. Suggestions to improve this professional development program include:

- Incorporate administrators in the training experience to promote their support, and provide tools to help them evaluate math-teaching performance.
- Provide teacher participants with training to read and interpret student test scores, which would allow them to monitor student progress throughout the school year and adjust their teaching accordingly.
- Spend more time with integrating other subjects and relaying real-world application in every lesson to help with improving assessment strategies.
- Provide teacher participants with a coding system they can use on daily blogs and journals to better analyze the change in knowledge and efficacy.
- Arrange for direct observations by experts, and provide on-going support following the summer institute and follow-up trainings.
- During summer institute, math professional experts should model for teachers how to analyze student math work. This would demonstrate how teachers could gain information about students' understanding of concepts and skills and can help them make instructional decisions for improving student learning.

In conclusion, this evaluation offers evidence that can be used to make decisions about the value and worth of this professional development program's efforts. In 2004-2005, the federal government spent close to 1.5 billion on professional development for teachers (Birman et al, 2007). Much of this professional development money is spent on small-scale programs such as the one included in this study, which cost close to $300,000. Given the critical role of professional development in school improvement efforts, and although this evaluation design had its limitations, the information gathered in this study is relevant and meaningful to decision makers in not only the participating school districts, but also the State Department of Education.

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APPENDIX A. PRIME and STAT Activities

Project PRIME Activities:

(1) Geometry and Measurement: Framed by a strong content foundation, the institute was designed to equip teacher participants with the knowledge and skills necessary to present instructional programs which will enable all their students to:

- develop measurement number sense using models;
- measure objects with nonstandard and standard units;
- find reasonable estimates for measurements using standard and metric units;
- establish benchmarks for customary and metric units;
- select and use appropriate units of measurement [customary and metric units] in problem solving and everyday situations;
- convert basic measurements of volume, weight, and distance within the same system for metric and customary units; compare, estimate, and determine measures of angles; describe and compare two and three dimensional shapes;
- describe properties of triangles and quadrilaterals and use these properties to solve problems in everyday situations;
- differentiate between congruent and similar figures, and find measures of angles and corresponding sides;
- construct models and classify solid figures by type;
- develop the Pythagorean Theorem and apply the formula to find the length of
- missing sides of a right triangle and the length of other line segments; find the perimeter and area of two dimensional shapes;
- find the volume and surface area of three-dimensional shapes; and convert basic measurements of volume, weight, and distance within the same system for metric and customary units.

(2) Fractional Concepts and Computation: Framed by a strong content foundation, the institute was designed to provide teacher participants with the

knowledge and skills necessary to present instructional programs which will enable all their students to:

- develop fractional number sense using models; compare and order fractions using models;
- identify and model equivalent fractions; compare, convert, and order common fractions and decimals to the 100ths place to solve problems;
- represent with models the connection between fractions, decimals, and percent and be able to convert from one representation to another (e.g., use 10 x 10 grids, base-10 blocks; limit fractions to halves, fourths, fifths, and tenths);
- explain verbally with manipulatives and diagrams 25%, 50%, 75%;
- use these percent to solve problems and relate to their corresponding fractions and decimals; apply estimation skills to solve problems involving common percent and equivalent fractions; add and subtract fractions and mixed numbers to solve problems using a variety of methods; multiply and divide fractions and mixed numbers to solve problems using a variety of methods; convert, compare and order decimals, fractions and percent using a variety of methods;
- and, estimate solutions to single and multi-step problems using whole numbers, decimals, fractions, and percent and assess whether solutions are reasonable.

Project STAT Activities:

(1) Data Analysis: Framed by a strong content foundation, the institute was designed to provide teacher participants with the knowledge and skills necessary to present instructional programs which will enable all their students to:

- pose questions, collect, record, and interpret data to help solve problems;
- using both white boards and manipulatives, construct bar graphs, frequency distributions, line graphs, and pictographs with appropriate labels and a title from a set of data;
- read graphs and charts, draw conclusions, and make predictions based on data;

- collect, organize, and record data in tables and graphs;
- compare displays of data and justify selection of type of table or graph for set of data;
- select, analyze, and apply data displays in appropriate formats to draw conclusions and solve problems;
- determine mean, the mode, median, mid-range, range, and standard deviation of a set of data;
- explain why a specific measure of central tendency provides the most useful information in a given context.

(2) Probability: Framed by a strong content foundation, the institute instructed participants with a goal of gaining the knowledge and skills necessary to present instruction, which will enable all their students to:

- describe the probability (more, less, or equally likely) of chance events;
- predict the probability of outcomes of simple experiments using words such as certain, equally likely, impossible, (e.g., coins, number cubes, spinners);
- determine the probability of events occurring in familiar contexts or experiments and express probabilities as fractions from zero to one (e.g., find the fractional probability of an event given a biased spinner);
- use fundamental counting principles on sets with up to four or four items to determine number of possible combinations (e.g., create a tree diagram to see possible combinations);
- determine probability of an event involving “or,” “and,” or “not,” (e.g., on a spinner with one blue, two red, and two yellow sections, what is the probability of getting a red or yellow?);
- connect one area or idea of mathematics to another (e.g., relates equivalent number representations to each others, relate experiences with geometric shapes to understanding ration and proportion), and connect one area or idea of mathematics to another subject;

- use a variety of representations to model and solve physical, social, and mathematical problems (e.g., geometric objects, pictures, charts, tables, graphs);
- use technology to generate and analyze data and solve problems;
- use counter examples to disprove suppositions (e.g., all squares are rectangles, but are all rectangles squares?).

APPENDIX B. PRIME Content Knowledge Pre/Post Test

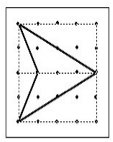
Summer Institute **Name:** ______________
Summer 2009

Written Assessment:
Problem Solving, Geometry, and Measurement

Instructions: Apply modeling experiences related to problem solving, geometry, and measurement as you respond to each of the test items given below. Circle the letter of the best answer to each question.

1. Find the area of the shape on the Geoboard.

a. 4 Geoboard Square Units
b. 4 ½ Geoboard Square Units
c. 5 ½ Geoboard Square Units
d. 6 Geoboard Square Units
e. 6 ½ Geoboard Square Units



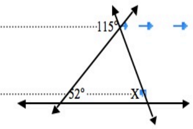
2. Which statement is always true?

a. Every rectangle is a rhombus.
b. Every quadrilateral is a rectangle.
c. Every square is a rectangle.
d. Every rectangle is a square.

3. What is true about the lengths of the three segments 5 cm, 9 cm, and 13 cm?

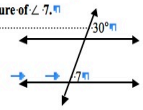
a. The lengths can form a triangle.
b. The lengths cannot form a triangle.
c. The lengths can form an isosceles triangle.
d. Both options A and C.

4. Find the measure of ∠ x:



a. 65 degrees
b. 52 degrees
c. 63 degrees
d. 49 degrees

5. Parallel lines are cut by a transversal. Find the measure of ∠ 7.



a. 30 degrees
b. 150 degrees
c. 134 degrees
d. 46 degrees

6. Problem Solving: Pick a number and add 4 to it. Find the sum of the new number and the original number. Add 8 to the sum. Divide the sum by 2 and subtract the original number from the quotient. Make a conjecture about the relationship between the original number and the final number.

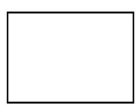
a. The final number will always be 6.
b. The final number is two less than the original number.
c. The final number is the same as the original number.
d. The final number is twice the original number.
e. The final number will sometimes be 6. It just depends on what number you begin with.

7. How many lines of symmetry does the yellow pattern block have?

a. 4
b. 6
c. 8
d. None of the Above

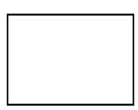
8. You are given a rectangle with dimensions (length and width) of 4 in x 6 in. Find the dimensions of another rectangle with the same area and yet a different perimeter.

a. 3 x 8
b. 3 x 7
c. 4 x 8
d. 10 x 2
e. 5 x 5



9. You are given a rectangle with dimensions (length and width) of 4 in x 6 in. Give the dimensions of another rectangle with the same perimeter and yet a different area.

a. 3 x 8
b. 3 x 7
c. 4 x 8
d. 10 x 2
e. 12 x 2



10. Problem Solving: How many cans are there in a grocery store display if there are 24 on the bottom row, 23 on the next row up, and so on, with 1 can on the top row?

a. 264
b. 280
c. 296
d. 300
e. 320

11. Which of the statements below explains the relationship between ∏ and 3.14?

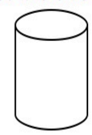
a. ∏ is rational and 3.14 is irrational so they are not equal.
b. ∏ is irrational and 3.14 is rational so they are not equal.
c. ∏ is the ratio of the circumference divided by the diameter.
d. Both B and C
e. Both A and C

12. Which is not true about pentominoes?

a. There are exactly 12 pentominoes.
b. All the pentominoes have an area of 5 square inches.
c. All the pentominoes have a perimeter of 12 inches.
d. The "X" pentominoe matches itself after a 90° rotation.

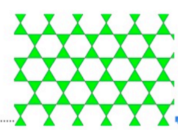
13. A manufacturer sells shampoo in a jar in the shape of a cylinder that is 9" tall and that has a base with a diameter of 3". Another manufacturer sells shampoo in a conical (cone) container that has the same height and base diameter. Which of the following statements is true?

a. The cone holds about half as much as the cylinder.
b. The cylinder holds about 3 times as much as the cone.
c. The cylinder holds about 1/3 as much as the cone.
d. Two cones hold about as much as the cylinder.



14. Which type of tessellation is given below?

a. Regular Tessellation
b. Semi-Regular Tessellation
c. Escher-Type Tessellation
d. None of the Above



15. Problem Solving: A frog falls into a well that is 18 feet deep. Every day the frog jumps up a total distance of 6 feet. At night, as the frog grips the slimy well walls, it slips back down by 2 feet. At this rate, how many days will it take the frog to jump to the rim of the well?

a. Day 3
b. Day 4
c. Day 5
d. Day 6

16. What must the sum of the angles about a vertex point in a tessellation be in order to prevent any gaps or overlaps?

a. 360°
b. 180°
c. 90°
d. 135°

17. Which of the statements given below is false?

a. Equilateral triangles will tessellate the plane.
b. Squares will tessellate the plane.
c. Regular hexagons will tessellate the plane.
d. Regular pentagons will tessellate the plane.

18. Problem Solving: Four weary and hungry travelers came upon an inn. The innkeeper told the travelers that the only food he had was potatoes. While the potatoes cooked, the travelers took a nap. Soon, one of the travelers awoke and saw the plate of potatoes. He ate 1/3 of the potatoes. The second traveler awoke and ate ½ of the remaining potatoes. The third traveler awoke and ate ½ of the remaining potatoes. The fourth traveler awoke and ate 2/3 of the remaining potatoes. The innkeeper returned to find only two potatoes left. How many potatoes did the innkeeper cook to begin with?

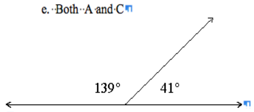
a. 12
b. 20
c. 24
d. 36
e. 42

19. Determine how many millimeters are in 1 decimeter.

a. 10
b. 100
c. 1000
d. 1/10
e. 1/1000

20. Which term (s) below describe the sketch?

a. Adjacent Angles
b. Complementary Angles
c. Linear Pair
d. Both A and B
e. Both A and C



Item Solution	Objective	Day Objective is Addressed via Modeling in Summer Institute
1. Choice D	Measurement – Area	Day 4
2. Choice C	Geometry – Quadrilaterals	Day 2
3. Choice A	Geometry – Triangles	Day 2
4. Choice C	Geometry – Angles/ Triangle Relationships	Day 2
5 Choice A	Geometry – Angle Relationships	Day 2
6. Choice A	Problem Solving Strategies – Algebraic Thinking/ Look for a Pattern	Day 1
7. Choice B	Geometry – Symmetry	Day 2
8. Choice A	Measurement – Area/ Perimeter	Day 4
9. Choice B	Measurement – Area/ Perimeter	Day 4
10. Choice D	Problem Solving Strategies – Draw/ Act Out/ Pattern	Day 1
11. Choice D	Measurement – Discovery of Pi	Day 4
12. Choice C	Problem Solving, Geometry, Measurement	Day 1 and Day 4
13. Choice B	Measurement – Relationships Among Solids	Day 4
14. Choice B	Geometry – Tessellations	Day 3
15. Choice B	Problem Solving – Pattern/	Day 1
16. Choice A	Geometry – Tessellations	Day 3
17. Choice D	Geometry – Tessellations	Day 3
18. Choice D	Problem Solving – Work Backwards/ Rational Numbers	Day 1
19. Choice B	Measurement – SI System	Day 3
20. Choice E	Geometry – Angle Relationships	Day 2

APPENDIX C: STAT Content Knowledge (Data Analysis & Probability) Pre/Post Test

Project STAT Name ____________________

Data Analysis Pre/Post-Test

Select the best answer to each of the following.

1. The best graphical data illustration to summarize trends over time is:
   a. a stem-and-leaf plot
   b. a histogram
   c. a circle graph
   d. a line graph
   e. a bar graph answer: ________

2. A dot plot is useful to:
   a. summarize information from large sets of data naturally grouped into intervals.
   b. represent relative parts of a whole.
   c. compare sets of data.
   d. summarize trends.
   e. summarize relatively small sets of data. answer: ________

3. A frequency polygon is also known as:
   a. a frequency distribution.
   b. a line graph.
   c. a bar graph.
   d. a histogram.
   e. a box-and-whisker plot. answer: ________

4. The number of classes in grouped data should be
   a. 8 to 12.
   b. 5 to 12.
   c. 6 to 10.
   d. 5 to 10.
   e. 6 to 15. answer: ________

5. The best graphical data illustration to illustrate a household budget would be:
   a. a bar graph.
   b. a histogram.
   c. a circle graph.
   d. a box-and-whisker plot.
   e. a stem-and-leaf plot. answer: ________

6. The best graphical data illustration to summarize weight loss on a diet would be:
   a. a circle graph.
   b. a bar graph.
   c. a histogram.
   d. a line graph.
   e. a dot plot. answer: ________

7. Which of the following would be the most appropriate to indicate the most popular type of pet among a group of students?
   a. mean
   b. mode
   c. median
   d. midrange
   e. midpoint answer: ________

8. Suppose a set of scores is described by the following: mean = 70, mode = 65, median = 68, and midpoint = 67. Which of the scores listed below **MUST** have actually been attained by some students?
   a. 65
   b. 67
   c. 68
   d. 70
   e. all of these must have actually occurred answer: ________

9. A sample drawn in such a way that every possible member has an equal chance of being chosen is:
   a. equally likely.
   b. fair.
   c. a random sample.
   d. unlikely.
   e. equal distribution. answer: ______

10. The greatest data value is added to the least data value and the sum is divided by 2. The result is the:
    a. mean.
    b. mode.
    c. median.
    d. midrange.
    e. range. answer: ________

11. Find the median of the following values.
    148, 139, 124, 122, 123, 144, 142, 133, 124, 141
    a. 133.5
    b. 124
    c. 134
    d. 136
    e. 135 answer: __________

12. Find the mean of the following values.
    148, 139, 124, 122, 123, 144, 142, 133, 124, 141
    a. 133.5
    b. 124
    c. 134
    d. 136
    e. 135 answer: __________

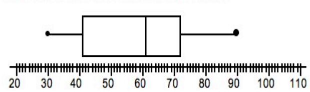
13. What number represents the lower quartile (Q_1) for the following data?
    22, 25, 34, 54, 45, 61, 24, 38, 42, 50, 44, 43, 37, 51, 47, 35, 49, 39
    a. 35
    b. 42.5
    c. 45
    d. 49
    e. 51 answer: __________

14. Find the angle measurement for the portion of the circle graph for the amount spent on utilities for the following data.

    Rent............$450
    Phone..........$150
    Food............$375
    Gas...............$75
    Utilities........$300
    Car..............$150

    a. 0.2°
    b. 20°
    c. 50°
    d. 72°
    e. 500° answer: __________

15. What is the upper quartile for the data represented by this graph?



    a. 30
    b. 41
    c. 61
    d. 72
    e. 90 answer: ________

Data Analysis Pre-Test Answers

1. d
2. e
3. b
4. b
5. c
6. d
7. b
8. a
9. c
10. d
11. d
12. c
13. a
14. d
15. d

Parrott
Summer 2010

Name: ____________________

Project STAT
Probability Pre/PostTest

Select the best answer to each of the following items.

1. Evaluate 8! ÷ 4!

   a. 2
   b. 2!
   c. 1680
   d. 2,442

   Solution: ____________________

2. Andy is a snack vendor at a baseball stadium. He has sold 215 packages of peanuts, 310 boxes of popcorn, and 75 hot dogs. What is the empirical probability that the next snack he sells will be a hot dog?

   a. 0.158
   b. 0.125
   c. 0.358
   d. 0.483
   e. 0.517

   Solution: ____________________

3. Evaluate the given statement: $_6P_2$ = ____

   a. 720
   b. 360
   c. 30
   d. 12
   e. 120

   Solution: ____________________

4. Twelve slips of paper with the numbers 1 through 12, respectively, are placed in a box, and one slip of paper is drawn. What is the probability that the slip of paper selected has a number less than 8?

   a. 7/12
   b. ½
   c. 2/3
   d. 5/12
   e. 1/12

   Solution: ____________________

5. A specific brand of bike comes in two frames, for males and females. Each frame comes in a choice of two colors, red and blue, and with a choice of three seats, soft, medium, and hard. Determine the number of different arrangements of bicycles that are possible. You may wish to construct a tree diagram to help you consider the sample space.

   a. 7
   b. 12
   c. 20
   d. 32
   e. 60

   Solution: ____________________

6. A die is rolled. Find the odds in favor of rolling a 2.

   a. 1:6
   b. 1:4
   c. 1:5
   d. 1:3
   e. 1:2

   Solution: ____________________

7. From a group of ten honor students, three students are to be chosen to represent the school in an academic competition. In how many different ways can the selection be made?

   a. 30
   b. 60
   c. 120
   d. 360
   e. 720

   Solution: ____________________

8. Two balls are selected **without replacement** from a bag containing one blue, one yellow, one green, one red, one brown, and one black ball. How many points are in the sample space?

   a. 12
   b. 6
   c. 10
   d. 25
   e. 30

   Solution: ____________________

Parrott
Summer 2010

Name: ____________________

Project STAT
Probability Pre/PostTest

Select the best answer to each of the following items.

1. Evaluate 8! ÷ 4!

   a. 2
   b. 2!
   c. 1680
   d. 2,442

   Solution: ____________________

2. Andy is a snack vendor at a baseball stadium. He has sold 215 packages of peanuts, 310 boxes of popcorn, and 75 hot dogs. What is the empirical probability that the next snack he sells will be a hot dog?

   a. 0.158
   b. 0.125
   c. 0.358
   d. 0.483
   e. 0.517

   Solution: ____________________

3. Evaluate the given statement: $_6P_2$ = ____

   a. 720
   b. 360
   c. 30
   d. 12
   e. 120

   Solution: ____________________

4. Twelve slips of paper with the numbers 1 through 12, respectively, are placed in a box, and one slip of paper is drawn. What is the probability that the slip of paper selected has a number less than 8?

   a. 7/12
   b. ½
   c. 2/3
   d. 5/12
   e. 1/12

   Solution: ____________________

5. A specific brand of bike comes in two frames, for males and females. Each frame comes in a choice of two colors, red and blue, and with a choice of three seats, soft, medium, and hard. Determine the number of different arrangements of bicycles that are possible. You may wish to construct a tree diagram to help you consider the sample space.

   a. 7
   b. 12
   c. 20
   d. 32
   e. 60

   Solution: ____________________

6. A die is rolled. Find the odds in favor of rolling a 2.

   a. 1:6
   b. 1:4
   c. 1:5
   d. 1:3
   e. 1:2

   Solution: ____________________

7. From a group of ten honor students, three students are to be chosen to represent the school in an academic competition. In how many different ways can the selection be made?

   a. 30
   b. 60
   c. 120
   d. 360
   e. 720

   Solution: ____________________

8. Two balls are selected **without replacement** from a bag containing one blue, one yellow, one green, one red, one brown, and one black ball. How many points are in the sample space?

   a. 12
   b. 6
   c. 10
   d. 25
   e. 30

   Solution: ____________________

Parrott
Summer 2010

Project STAT
Probability Pre-Test Solutions:

1. C
2. B
3. C
4. A
5. B
6. C
7. C
8. E
9. D
10. C
11. B
12. C
13. D
14. C
15. D

Appendix D: Responses from participants to show if their efficacy increased teaching mathematics content (*Denotes a teacher's response)

1-5 Years Experience
*My knowledge in all the categories was greatly strengthened. I feel more confident in my instructional practices because of these summer institutes. It was a GREAT refresher after my college classes.
*I have fallen in love with teaching Math! I used to have a secret hatred for the subject and was far more confident in my ability to teach Reading. Now I know I can teach Math, and I have been given so many ways to make me a better teacher because of PRIME and STAT. I feel like my students are gaining more from my classes than ever before.
*I learned a lot more ways to teach geometry and fractions.
6-15 Years Experience
*I think the networking with other teachers and professors helped broaden the collective understanding of the subject matter. Even though at my school there are only a few problems on the state test regarding probability and data analysis, I know that my students had a better understanding of the concepts because of what I learned at STAT.
*I do many more activities that carry through more than one day. I also learned several ways of using hands on activities that I hadn't used before. I felt much more comfortable and knowledgeable in the content that was covered in Project STAT.
*Project PRIME/STAT has helped me to enhance what I teach by adding a deeper dimension to my lessons. My own knowledge and understanding has been greatly affected by my participation in Project PRIME/STAT. These professional development opportunities have encouraged me to incorporate more data analysis, creation of charts and graphs, technology, and hands-on activities that have helped my students grow in their understanding and use of mathematics. I have also been able to more closely relate and integrate math and science in my lessons.

*I've learned many ways to make learning the objective more hands on instead of just problems out of a math book. I use more hands-on activities. I see the need to understand things at a deeper level and I feel more comfortable teaching these concepts.
*My use of math vocabulary has increased greatly after attending Project STAT. I am also more confident in teaching probability and data analysis and look forward to teaching these units. I think more about applying hands on activities.
*Gave me new ideas, and touched on specific topics. I have incorporated more hands on activities. I also have brought back more conceptual learning for my students. Project STAT provided some great hands-on instructional activities for use in the classroom. I'm offering more activities that guide students to understanding the concepts instead of just following procedures because "that's how you do it."
*My content knowledge has increased because of my involvement with Project PRIME/STAT. I have been able to engage my students in various hands-on mathematics/science related activities that help them gain a deeper understanding of mathematics/science concepts. In turn, this enhances student achievement, student involvement, and an overall stronger appeal to students struggling in these subject areas.
*I feel better prepared to teach my students and feel more confident in my explanations to them of the content I teach. I do a little more hands on activities with my students because of what I learned.

16+ Years Experience

*I think it all helped me. I was increasing my knowledge base the entire time. The professors were very knowledgeable about their content and the subject material. I was collaborating with them about how I would use manipulatives more in my classroom. I was increasing skills to become more prepared for more hands-on experiences for the students. I became more technology oriented and therefore feel more competent with my promethean board. I think I am a better teacher now.
*Still technophobic

* While I gained a deeper knowledge in content in mathematics, I felt that the content that I could actually take back to my students through hands-on applicable activities was the most useful to me.
* I felt like all the projects helped me to develop activities and increase my knowledge in the area of math. I walked away with many lessons and lesson plans that incorporated technology. *I tried many of them in my classroom and my students loved the hands on approach to teaching math. I look forward to seeing the difference in my state testing scores in math this year.
* I believe meeting with the professors helped excite me again about teaching. It also showed me that I could try new things and if they are successful that was great and if they weren't then that is OK as well.
* Dr. Parrott always has great ideas that we can take to the classroom. I also feel more confident in teaching the statistical part of math. I feel that this experience has been a career changing experience!
* I feel STAT accomplished it's purpose. At the end of the program I had many new ideas to integrate into my lessons on the related objectives. I also learned a few new things in the technology department where I can use all the help I can get!!
* My knowledge of the subject matter increased, as well as my use of technology in the classroom in connection with the lessons explored and extended. By putting myself in the position of student rather than teacher, gave me a much better insight as to dealing with student frustration and mastery of concepts taught, and the need to step up the technology components of my lessons.
* After participating in Project STAT I felt more confident in teaching the math concepts that I was weak. I learned a lot of practical uses for the math, and most of all I enjoyed the participation with other teachers.
* At first I was excited about participating in Project STAT because of the stipend. After attending I have gained much knowledge of science, math, engineering and technology and have been able to successfully integrate it across the curriculum to better educate my students. I feel that I am a better teacher because of it!

* I feel that the project did increase my subject knowledge. I loved going through the scope and sequence of why my 3rd grade skill is important to other years. I knew this for some skills but did not fully understand some skills where they led.
*I think the networking with other teachers and professors helped broaden the collective understanding of the subject matter. Even though at my school there are only a few problems on the state test regarding probability and data analysis, I know that my students had a better understanding of the concepts because of what I learned at STAT.
* I felt like all of the activities/lessons were useful – some were above my grade level. * At first I felt concerned about some of the Math I taught. Now I do more graphing, probability, surveys and for sure more fractions. I feel I am much more confident that I am doing a better job at teaching these math concepts. I think I teach more thoroughly than I did before this training. We learned things I will not use. Each time I mastered a skill it gave me more knowledge and more confidence.
* More hands-on, more manipulatives, less rote and drill, more constructionism.
* Since attending Project STAT, I have tried to take more of a hands-on approach with my students. I used several of the activities that we did in the summer institute with my students and they were more confident in their ability to learn and retain their math skills. Their test scores improved also.
* I use more hands-on instruction in the classroom. I also use hands-on in reviewing the content taught. If a student forgets concept, I refer back to the time when we did a hands-on activity on the skill, saying something like, "Remember when we did ......" This seems to help them remember the concept.
* I feel much more prepared and capable after seeing actual teaching modeled at the training. I incorporate technology a LOT more, and have a lot of material that I did not know existed before attending.
* I have tried to do more hands on activities.
* I feel more knowledgeable about the subject matter.
* I have learned to use more real life situations in teaching probability, fractions, and etc.

* I think more about applying hands on activities.
* I feel I do more hands-on teaching in math with the activities/ideas from the Project. Also, the Project was very influential in providing ideas, including websites for the classroom teacher/student. I was very impressed, too, with the motivational level of the Project instructors. I feel have been more motivational in my own teaching style due to their influence.
* I have increased the time and depth of lessons on Probability and Data Analysis.
* I use more hands on, especially with measurement and problem solving.
* STAT introduced me to a lot of new ideas for probability. I extended these to my class with hands on activities and my students really seemed to have a good grasp of the concept. We also had fun with some of the materials we used.
* It gave ways to make learning these new concepts more interesting and exciting for the students. I got a lot of new ideas and hands on activities to use in the classroom.
* I am really trying to use a more hands-on approach to the concepts that we have covered, as well as extending the basic knowledge.
* I have become more aware of the importance of incorporating math into the other subject areas. I have also used more hands-on activities that I've used what I learned to help my students learn math.
* Through both of these institutes I have gained the knowledge to instruct my students in a more thorough manner. I have used many of the lessons that have been presented to us to help my students better understand the concepts.
* After the last two summers I have changed the way I allow the students to find their way of finding the answer and then we work more on the how and why explanations. I use many different approaches to each skill. I learned the importance of using all different methods.
* Due to being involved with project STAT I incorporated more hands on learning for the students. I felt that in doing so I gave them a more concrete background than I had before.

Appendix E: Responses from Participants to show if their efficacy increased in using technology and manipulatives in Math teaching (*Denotes a teacher's response)

1-5 Years Experience
*My knowledge in all the categories was greatly strengthened. I feel more confident in my instructional practices because of these summer institutes. It was a GREAT refresher after my college classes.
*The manipulatives helped me more than anything. Before I went to PRIME and STAT my manipulatives lived in the cabinet, and was only brought out with things I knew how to use! Now they live on my shelves, and we are using them all the time with every grade level!
*They've given me a lot more hands-on ideas to prove why the formulas work.
*I have become more project based because of project prime, I use more innovative ways to teach material as well.
*I use manipulatives more effectively and feel my explanations have improved greatly.

6-15 Years Experience
*All of the math was helpful, whether a new area or a refresher. It made me re-evaluate the ways I was teaching. I also felt the field trips were enlightening on how much I actually knew. I also walked away with new techniques for teaching the concepts.
*Project PRIME/STAT has helped me to enhance what I teach by adding a deeper dimension to my lessons. My own knowledge and understanding has been greatly affected by my participation in Project PRIME/STAT. These professional development opportunities have encouraged me to incorporate more data analysis, creation of charts and graphs, technology, and hands-on activities that have helped my students grow in their understanding and use of mathematics. I have also been able to more closely relate and integrate math and science in my lessons.
*I've learned many ways to make learning the objective more hands-on instead of

just problems out of a math book. I use more hands-on activities. I see the need to understand things at a deeper level and I feel more comfortable teaching these concepts.

*I am now more confident in my content knowledge and better able to give my students immediate and helpful feedback when I'm teaching the skills I learned during the summer institute.

*My use of math vocabulary has increased greatly after attending Project Stat. I am also more confident in teaching probability and data analysis and look forward to teaching these units. I think more about applying hands on activities.

*I now realize the importance of giving my students the opportunity to use hands-on activities to reinforce their math skills. I am using them more and plan to continue increasing those types of activities.

*Gave me new ideas, and touched on specific topics I have incorporated more hands on activities. I also have brought back more conceptual learning for my students. Project STAT provided some great hands-on instructional activities for use in the classroom. I'm offering more activities that guide students to understanding the concepts instead of just following procedures because "that's how you do it."

*My content knowledge has increased because of my involvement with Project PRIME/STAT. I have been able to engage my students in various hands-on mathematics/science related activities that help them gain a deeper understanding of mathematics/science concepts. In turn, this enhances student achievement, student involvement, and an overall stronger appeal to students struggling in these subject areas.

*I feel better prepared to teach my students and feel more confident in my explanations to them of the content I teach. I do a little more hands on activities with my students because of what I learned.

16+ Years Experience

*I think it all helped me. I was increasing my knowledge base the entire time. The professors were very knowledgeable about their content and the subject material. I was collaborating with them about how I would use manipulatives more in my classroom. I was increasing skills to become more prepared for more hands-on experiences for the students. I became more technology oriented and therefore feel more competent with my promethean board. I think I am a better teacher now.

*Still technophobic

* I have definitely "thought out of the box" a great deal more. I use manipulatives more frequently and hands-on projects more often. I have also incorporated technology in my everyday math lessons. The students really enjoy the days that we work together in groups using laptops, etc. Technology has even changed the way I do assessments in my classroom.

* I felt like all the projects helped me to develop activities and increase my knowledge in the area of math. I walked away with many lessons and lesson plans that incorporated technology. *I tried many of them in my classroom and my students loved the hands on approach to teaching math. I look forward to seeing the difference in my state testing scores in math this year.

`* I believe meeting with the professors helped excite me again about teaching. It also showed me that I could try new things and if they are successful that was great and if they weren't then that is OK as well.

* Dr. Parrott always has great ideas that we can take to the classroom. I also feel more confident in teaching the statistical part of math. I feel that this experience has been a career changing experience!

*The use of ice cream and flavors to demonstrate combinations was great. I have used food to demonstrate combinations, fractions, estimation, and probability with my special needs kids. It "sticks" better than other methods of teaching and the kids love it. They think I'm a great teacher. ha Getting to eat what you work with is always fun!

* I felt the entire program helped me with the intended purpose.

* I can't say there were any parts of the projects that did not help me.

Some lessons were not as interesting as others; however, I valued everything.

* I would always want to be better prepared to develop lesson plans, use

manipulatives and technology but the stipend was most important in my consideration of participating. It would be hard to give up that much time without being compensated. As teachers we do that enough every day. The fraction part was difficult but did help me see how the students need to figure out the meaning. It was challenging but an eye opener. I saw how important it is for students to grasp the concept and know the reasoning behind everything.

* I feel STAT accomplished it's purpose. At the end of the program I had many new ideas to integrate into my lessons on the related objectives. I also learned a few new things in the technology department where I can use all the help I can get!!

* My knowledge of the subject matter increased, as well as my use of technology in the classroom in connection with the lessons explored and extended. By putting myself in the position of student rather than teacher, gave me a much better insight as to dealing with student frustration and mastery of concepts taught, and the need to step up the technology components of my lessons.

* In each area there were hands on activities. I am a hands-on learner and therefore it made things easier to apply and in turn teach it to my kids.

* I felt like all of the activities/lessons were useful – some were above my grade level. * At first I felt concerned about some of the Math I taught. Now I do more graphing, probability, surveys and for sure more fractions. I feel I am much more confident that I am doing a better job at teaching these math concepts. I think I teach more thoroughly than I did before this training. We learned things I will not use. Each time I mastered a skill it gave me more knowledge and more confidence.

* More hands-on, more manipulatives, less rote and drill, more constructionism

* Since attending Project STAT, I have tried to take more of a hands-on approach with my students. I used several of the activities that we did in the summer institute with my students and they were more confident in their ability to learn and retain their math skills. Their test scores improved also.

* I use more hands-on instruction in the classroom. I also use hands-on in reviewing the content taught. If a student forgets concept, I refer back to the time

when we did a hands-on activity on the skill, saying something like, "Remember when we did ......" This seems to help them remember the concept.
* I feel much more prepared and capable after seeing actual teaching modeled at the training. I incorporate technology a LOT more, and have a lot of material that I did not know existed before attending.
* I have tried to do more hands on activities.
* I think more about applying hands on activities.
* I feel I do more hands-on teaching in math with the activities/ideas from the Project. Also, the Project was very influential in providing ideas, including websites for the classroom teacher/student. I was very impressed, too, with the motivational level of the Project instructors. I feel have been more motivational in my own teaching style due to their influence.
* I use more hands-on, especially with measurement and problem solving.
* STAT introduced me to a lot of new ideas for probability. I extended these to my class with hands on activities and my students really seemed to have a good grasp of the concept. We also had fun with some of the materials we used.
* It gave ways to make learning these new concepts more interesting and exciting for the students. I got a lot of new ideas and hands on activities to use in the classroom.
* I am really trying to use a more hands-on approach to the concepts that we have covered, as well as extending the basic knowledge.
* I have become more aware of the importance of incorporating math into the other subject areas. I have also used more hands-on activities that I've used to help my students learn math.
* Due to being involved with project STAT I incorporated more hands-on learning for the students. I felt that in doing so I gave them a more concrete background than I had before.
* I learned new hands on activities to teach some concepts.
* I am more aware of the hands-on that is needed in order for students to understand and to be successful.
* I was able to use more hands-on activities with my students and students seem

to be grasping the content a lot quicker than in past years.

Appendix F: IRB Approval

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects
Approval of Initial Submission – Exempt from IRB Review – AP01

Date: October 07, 2013 **IRB#:** 3479

Principal Investigator: Jacque Sue Canady, Ed.D. **Approval Date:** 10/04/2013

Exempt Category: 2

Study Title: Mathematics Professional Development Program Evaluation3rd - 8th grade teachers

On behalf of the Institutional Review Board (IRB), I have reviewed the above-referenced research study and determined that it meets the criteria for exemption from IRB review. To view the documents approved for this submission, open this study from the *My Studies* option, go to *Submission History*, go to *Completed Submissions* tab and then click the *Details* icon.

As principal investigator of this research study, you are responsible to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Request approval from the IRB prior to implementing any/all modifications as changes could affect the exempt status determination.
- Maintain accurate and complete study records for evaluation by the HRPP Quality Improvement Program and, if applicable, inspection by regulatory agencies and/or the study sponsor.
- Notify the IRB at the completion of the project.

If you have questions about this notification or using iRIS, contact the IRB @ 405-325-8110 or irb@ou.edu.

Cordially,

Lara Mayeux

Lara Mayeux, Ph.D.
Chair, Institutional Review Board