LONG-TERM USE OF STANDARDS-BASED INSTRUCTIONAL PRACTICES IN MATHEMATICS CLASSROOMS IN SOUTHWESTERN PENNSYLVANIA

by

Jacquelyn Anderson Removcik

B.S., Allegheny College, 1999

M.Ed., University of Pittsburgh, 2005

Submitted to the Graduate Faculty of

Administration and Policy Studies

School of Education

in partial fulfillment

of the requirements for the degree of

Doctor of Education

University of Pittsburgh

UNIVERSITY OF PITTSBURGH

School of Education

This dissertation was presented

by

Jacquelyn Anderson Removcik

It was defended

on

April 14, 2014

Advisor and Dissertation Chair: Dr. Cynthia Tananis, Associate Professor, Administrative and Policy Studies

Dr. Michael Gunzenhauser, Associate Professor, Administrative and Policy Studies

Dr. R. Gerard Longo, Clinical Associate Professor, Administrative and Policy Studies

Dr. Ellen Ansell, Associate Professor, Instruction and Learning

Dr. Nancy Bunt, Program Director of Math & Science Collaborative

LONG-TERM USE OF STANDARDS-BASED INSTRUCTIONAL PRACTICES IN MATHEMATICS CLASSROOMS IN SOUTHWESTERN PENNSYLVANIA

Jacquelyn Anderson Removcik, Ed.D.

University of Pittsburgh, 2014

In July 2010, the Pennsylvania Department of Education adopted the Common Core State Standards for Mathematics. Consequently, school districts are adopting and implementing Pennsylvania's Core Standards (PAC) beginning with the 2013-2014 school year. Encapsulated in the PAC are both content standards and process standards, and the Standards for Mathematical Practice of the PAC capture tenets of standards-based mathematics.

Professional development encouraging standards-based mathematics instruction was promoted during the Teacher Leadership Academies (TLAs) provided by the Math Science Partnership (MSP) of Southwestern Pennsylvania. Through these, teachers were provided professional development experiences reflecting research-based practices. The TLAs also advocated for the use of standards-based mathematical instructional practices. With the implementation of the PAC and the Standards for Mathematical Practice, standards-based mathematics instruction is a timely topic.

This study analyzed career trajectories and professional experiences of teachers who participated in the TLAs since their culmination in 2008. It also examined the self-reported frequency of mathematical instructional practices occurring in classrooms after the research-based professional development experience of the TLAs ended. This study categorized the instructional strategies into two types: traditional and standards-based. Finally, the study

identified potential barriers and supports which may have helped or hindered the continued use of standards-based practices.

Some stability exists across Southwestern Pennsylvania for teachers who participated in the TLAs; moreover, teachers who participated in the TLAs continue to use instructional practices reflective of traditional mathematics instruction and standards-based mathematics instruction. However, traditional mathematical instructional practices occur more frequently. As far as potential barriers and supports, barriers most often self-reported consisted of time and covering curriculum as required by high stakes standardized testing. The supports identified the most often addressed teacher beliefs concerning mathematics, content knowledge and pedagogical content knowledge. The greatest limitation of this study is the relatively small sample size, making it difficult to generalize the findings. However, the findings of this study still provide guidance for the implementation of standards-based instruction in classrooms today as called upon by the Standards for Mathematical Practice.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

I extend a heartfelt thank you to the many people who have been with me throughout this arduous process. First and foremost, I have to thank my husband, Jason. Without his support, patience, and sacrifice, this educational journey would not have been possible. It is because of you I have been able to achieve this much anticipated milestone. I also have to extend a sincere thank you to my daughter Juliet. Even though you will not remember this, you provided me with the strength and motivation to persevere with this work, and I love you both very much.

I would like to thank my mother, Debbie. You continue to be my role model. Your strength during times of adversity has often served as my inspiration. I would also like to thank my brothers: Billy, Mike and Chris. The three of you have always been supportive of my decisions, and I am eternally grateful. I would like to thank a few others who have provided some form of support allowing me to complete this process: Malena, Janet and Stacey. Each of you has contributed to my journey in your unique way and played a vital role in allowing me to complete it. Thank you all.

Finally, with much gratitude and appreciation, I have to thank Dr. Cynthia Tananis. Her guidance, wisdom, support and expertise have allowed me to fulfill this journey. She kept me progressing even when I thought I could not continue. In addition, I have to extend a tremendous thank you to my committee members, Dr. Ellen Ansell, Dr. Nancy Bunt, Dr.

Michael Gunzenhauser and Dr. Jerry Longo. Their expertise and feedback served to strengthen and clarify this study. I have appreciated each of your insights and contributions, and I know my work has benefited greatly from your expertise.

1.0 INTRODUCTION

For well over the past 20 years, U.S. students have continuously performed poorly in mathematics. In the past the performance of U.S. students on the Second International Mathematics Study and the International Assessment of Educational Progress was weak (Herrera & Owens, 2001; Stigler & Hiebert, 1997). Coupling this poor performance on national and international tests, a dismal picture for U.S. students and their ability to engage and do mathematics has emerged (Herrera & Owens, 2001). The Trends in International Mathematics and Science Study (TIMSS) has been administered in 1999, 2003, 2007 and 2011 and continues to be administered. TIMSS compares the mathematical performance of students internationally, and the results of this assessment and other assessments such as the Program for International Student Assessment (PISA) continue to support the argument of reforming our mathematics classrooms.

In the 2011 administration of the TIMSS, U.S. fourth graders scored lower than eight international education systems including Singapore and Korea, and U.S. eighth graders scored lower than 11 international educational systems including Singapore and Korea (Buckley, 2012). Although there have been trends depicting recent gains on the mathematics portion of the National Assessment of Educational Progress (NAEP), concerns still exist as “the average mathematics score for 17-year-olds overall did not change significantly since 2004” (Rampey, Dion & Donahue, 2009, p. 40). As for the PISA, it is an international assessment administered every three years measuring the performance of 15-year-olds in reading literacy, mathematics literacy, and science literacy (Fleischman, Hopstock, Pelczar & Shelley, 2010). In the 2009 administration of the PISA, U.S. 15-year-olds scored an average of 487 on the mathematics literacy scale which was lower than the Organization for Economic Cooperation and Development (OECD) average score of 496 (Fleischman, Hopstock, Pelczar & Shelley, 2010).

As our world becomes increasingly competitive globally, the importance of strong mathematical skills for our students to compete with international competitors remains a concern, as evidenced by recent attention to Science, Technology, Engineering and Mathematics (STEM) campaigns. The results of the national and international assessments have caused an interest in studying the instructional strategies occurring in the classrooms of higher-performing countries; moreover, this has resulted in an interest in the types of professional development opportunities provided to mathematics teachers in higher-performing countries.

Throughout recent years, mathematics curricula have been revised to reflect state and national standards. The creation of the National Council of Teachers of Mathematics (NCTM) *Standards* and *Professional Standards for Teaching Mathematics* represented a major shift in thinking about teaching and learning and helped to move the discourse of mathematics to standards-based mathematics instruction as opposed to traditional mathematics instruction. In standards-based mathematics instruction, the NCTM *Standards* argued teachers:

> engage students in appropriate worthwhile tasks that promote conceptual understanding, skill acquisition, problem solving and reasoning; facilitate effective classroom discussion; ask meaningful questions; use tools such as manipulatives appropriately; establish a positive learning environment and reflect on their own practice. (Briars, 1999, p. 2)

Student-centered instructional practices are key components of standards-based mathematics instruction.

According to NCTM's *Professional Standards for Teaching Mathematics* (1991), in standards-based classrooms, teachers act as facilitators of student learning. *The Professional Standards for Teaching Mathematics* developed "a vision of what a teacher at any level of schooling must be able to do to teach mathematics as envisioned by NCTM Curriculum and Evaluation Standards for School Mathematics" (National Council of Teachers of Mathematics, 1991, p. 5). In these classrooms, teachers utilize instructional practices requiring students to work collaboratively and explain their thinking; the classroom environment is student-centered with the teacher acting as an orchestrator within the lesson. Students engage in mathematical tasks, and teacher reflection of instruction occurs regularly. Teachers plan experiences that allow students to construct mathematical meaning; moreover, there is a strong emphasis on authentic contexts, real-world connections and activity-oriented problem solving in an effort to foster greater conceptual understanding (Hudson, Miller, & Butler, 2006).

Creating this type of classroom may be a significant departure from the experiences many teachers themselves encountered in their own schooling. The NCTM's *Professional Standards for Teaching Mathematics* (1991) explained:

> the Curriculum and Evaluation Standards implies a significant departure from the traditional practices of mathematics teaching. It suggests changes in not only what is taught but also how it is taught. Teachers and students have different roles in such classrooms and different notions about what it means to know and to do mathematics (p. 20).

Establishing and creating standards-based classrooms may require substantial professional development experiences in order to create these student-centered classrooms.

To address growing national concerns about the educational performance of U.S. students in mathematics and science, the Math Science Partnership (MSP) was created by the National Science Foundation (NSF) (National Science Foundation, 2006). To qualify for MSP funding, a MSP project needed to be designed using educationally sound research-based strategies (National Science Foundation, 2006). In 2003, the Math & Science Collaborative (MSC) of Southwestern PA received funding from the NSF to execute its projects. This led to the creation of the Math Science Partnership of Southwestern Pennsylvania which provided mathematics and science teachers the opportunity to engage in research-based professional development focused upon both content knowledge and pedagogical content knowledge.

Several of the MSP professional development experiences included Teacher Leadership Academies, On-Site Academies, Principal Seminars, Teacher Fellows, Network Connections, Educator Networks and Content Deepening Seminars. Much of the participation in the MSP professional development opportunities occurred from participation in the Teacher Leadership Academies and corresponding On-Site Academies, which occurred primarily from 2004 to 2008. Teacher leaders were to conduct On-Site Academies in their home schools after their experience in the Teacher Leadership Academies. In 2004-2005, teacher leaders conducted 106 On-Site Academies in Southwestern Pennsylvania with 2,412 teachers participating (Bunt, 2006).

Through the MSP academies, teachers have been exposed to mathematical standards-based instructional strategies. Given the wide array of teachers the MSP academies have reached in Southwestern Pennsylvania, many teachers in this area have had some exposure to the standards-based instructional strategies promoted by the MSP. As a result, it is valuable to investigate if the practices prescribed in the MSP academies are still viable in classrooms across Western Pennsylvania now; moreover, it is also valuable to explore potential barriers and supports that may have affected the continued use of these practices over time.

1.1 STATEMENT OF THE PROBLEM

In July 2010, the Pennsylvania Department of Education adopted the Common Core State Standards for Mathematics. As a result, districts are expected to adopt and implement Pennsylvania's Core Standards (PAC) beginning with the 2013-2014 school year. The PAC standards derive from the Common Core Standards. The standards describe what students are to know and be able to do from pre-kindergarten to 12th grade. Encapsulated in these are both content standards and process standards.

With the release of the NCTM *Standards* in the 1990s, teachers started thinking about curriculum in terms of standards reflecting specific content that students were to know and be able to do upon the completion of a grade level. In recent years, Pennsylvania teachers have had to adjust and refine their curriculum and instructional practices to address such content standards; however, embedding process standards into the curriculum may be a relatively new activity for teachers. The Standards for Mathematical Practice "describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important 'processes and proficiencies' with longstanding importance in mathematics education" (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010, p. 6). This notion of process standards is relatively new to teachers.

In fact, the Standards for Mathematical Practice represent the first time Pennsylvania has officially adopted process standards for mathematics. As reflected in the PA Core Standards, the eight Standards for Mathematical Practice ask students to:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and make sense of regularity in repeated reasoning.

As they are written, the Standards for Mathematical Practice capture tenets of standards-based mathematics; furthermore, they also reflect process standards called upon by the NCTM *Standards* and the National Research Council's *Adding it Up* (2001). In addition, the Standards for Mathematical Practice require students to be engaged in mathematics differently than traditional, teacher-centered mathematics classroom experiences. According to Zimmermann, Carter, Kanold and Toncheff (2012), in a "classroom culture that extends beyond traditional, teacher-centered instruction, the teacher facilitates student engagement in mathematics related to the CCSS Mathematical Practices" (p. 28). The Standards for Mathematical Practice call for student-centered mathematical learning.

To provide this standards-based, student-centered mathematics instruction may require intensive professional development for teachers. This professional development will be both strategic and meaningful for teachers. If professional development is to affect and change mathematical instructional practices as required by the Common Core Standards/PA Core Standards, it will be sustained, grounded in content, and anchored in a teacher's professional practice (Briars, 1999; Hill, 2004; Walker, 2007).

The context for this study is the MSP of Southwestern PA. As previously mentioned, this MSP has offered sustained professional development experiences that were anchored in teachers' professional practice through the Teacher Leadership Academies (TLAs). The TLAs promoted the utilization of standards-based instructional practices; furthermore, the establishment of the TLAs centered upon research-based practices for adult learning. As a former participant of the MSP Teacher Leadership Academy, this study is important to me because it examines if the standards-based instructional strategies promoted continue to exist in teachers' classrooms well after the professional development experiences have ended.

This study is important to the literature at large because it examines if research-based professional development continues to affect a teacher's practice after a significant time period has passed. The significant time period referenced in this study refers to the six to ten years since teachers participated in the TLAs (2004-2008). Moreover, this study investigates the implementation of standards-based instructional practices years after the execution of the reform.

For this study, the researcher analyzed the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since the time of their participation. Furthermore, the study also examined if teachers who participated in TLAs currently self-report the use of standards-based instruction in their mathematics classrooms. Finally, this study examined self-reported perceptions of barriers and supports in schools that have affected the continued use of standards-based practices in mathematics classrooms over time. For educational administrators, it identifies potential supports and barriers contributing to the discourse as they work to engage their teachers in standards-based mathematical instruction reflecting the process standards of the PA Core Standards for Mathematical Practices.

1.2 RESEARCH QUESTIONS

Even though the MSP Teacher Leadership Academies were designed to align with the characteristics the literature defines as effective in terms of professional development, it is valuable to study how these experiences currently affect classroom instruction. Because the MSP professional development experiences used research-based practices and promoted standards-based instruction, information as to how teachers implement the standards-based instructional practices after participation in the TLAs furthers the discourse on teacher professional development as related to mathematics. In addition, the discussion of barriers and supports that affect the continued use of standards-based practices contribute to the conversation for school administrators as they transition to the Common Core. The following research questions are addressed in this study:

1. What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?
2. What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?

3. For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?

1.3 SIGNIFICANCE OF THE STUDY

1.3.1 PERSONAL SIGNIFICANCE

As a former high school mathematics teacher, I participated in the MSP Teacher Leadership Academies. This included the opportunity for me to facilitate the On-Site Academies within a former district. As a participant in the TLAs, I was able to experience the type of professional development the literature identifies as essential for changing practice. My participation in the TLAs provided me with standards-based instructional strategies to incorporate in my own classroom practice. I implemented the strategies in my classroom; moreover, I was able to directly observe the value for students engaging in standards-based, mathematical activities. The activities provided opportunities for my students to communicate their mathematical thinking and provided a means for me to gauge their understanding.

These ideas significantly shaped my view of mathematics instruction. When I left the classroom and assumed an administrative position as a high school assistant principal, this view of instruction shaped my work as the mathematics department supervisor. As a supervisor, I worked with mathematics teachers to incorporate standards-based strategies such as having students explain and justify their thinking. In addition, I facilitated a lesson study initiative with the mathematics department to engage in professional development designed to collaboratively strengthen classroom practice. Through these professional experiences, I developed an interest in the types of professional development experiences that are most likely to inform classroom mathematics practices.

In my current role as a curriculum specialist, much of my work is anchored in providing professional development to teachers. I understand how one-time professional development experiences do not lead to changing classroom practices, and my interest lies in developing a focused understanding of the types of professional development likely to promote and sustain the use of standards-based practices as called upon by the Standards for Mathematical Practice. Through this study, I have gained a deeper understanding of the types of professional development experiences that are likely to have long-term impacts on classroom practices. In addition, as an administrator, I have also increased my understanding of what school and district level factors help contribute to teachers' sustaining standards-based practices in classrooms over time.

1.3.2 SCHOLARSHIP AND PRACTICE SIGNIFICANCE

Reform efforts continue to dominate educational research and practice, and a plethora of research exists related to reform efforts occurring in schools and districts. However, persistence of reform efforts is typically not as often addressed. This study is valuable because it examined the issues of institutionalization relevant to educational reform efforts. Furthermore, this study identified the long-term use of standards-based instructional practices after teachers participated in the MSP TLAs.

This study also examined barriers and supports that may have contributed to the continued use of standards-based instructional strategies. The identification of such barriers and supports contribute to both the field of practice and scholarship. As administrators work with mathematics teachers to implement the Standards for Mathematical Practice, the identification of barriers and supports informs how they may be able to support their staff with the implementation and institutionalization of standards-based mathematical instructional practices. In addition, this study contributes to the field of scholarship by examining this issue of the institutionalization of a reform effort several years after the implementation occurred.

1.4 DEFINITION OF TERMS

The research study will use the following definitions for general terms.

1. **Standards-based mathematics instruction**—As defined by the NCTM's *Professional Standards for Teaching Mathematics* (2001), standards-based mathematics instruction encompass six standards: worthwhile mathematical tasks, the teacher's role in discourse, the student's role in discourse, tools for enhancing discourse, the learning environment, and the analysis of teaching and learning. Furthermore, standards-based mathematics instruction reflects a constructivist approach to teaching that emphasizes tasks, discourse, environment and reflection. According to Howley, Larson, Solange, Rhodes and Howley (2007),

> the standards [NCTM 1989 & 2000] support curricula that emphasize concepts and meaning rather than rote learning, they promote integrated rather than piecemeal treatment of mathematical ideas, and they encourage all students' engagement with high-

> level mathematics. The standards also emphasize an approach to pedagogy that fits with constructivist theories of learning. (p. 2)

In standards-based mathematics instruction, students are "actively involved constructing their own mathematical knowledge, not memorizing the steps of a teacher-directed algorithm or endlessly practicing a litany of procedures" (Alsup, 2005, p. 3). Teachers emphasize active learning with their students as they engage in interactive and problem-centered tasks (Alsup, 2005). Students are provided with opportunities to act on their environments in an effort to construct their own knowledge and learning stresses authentic and collaborative problem solving opportunities (Brown, 2003).

2. **<u>Traditional Mathematics Instruction</u>**—In traditional mathematics instruction, there is more focus on computations, procedures and rote learning; "the major theme is for teachers to demonstrate, and students to practice, formal symbolic procedures" (Battista, 2001, p. 43). Battista (2001) explained in a traditional math classroom:

> the first thing that happens in the instructional routine is that answers are given for the previous day's homework. Next, the teacher gives a brief description of new material, then assigns exercises to be completed for homework. The remainder of the period is devoted to students working independently on these exercises while the teacher circulates around the room answering students' questions. (p. 43)

In traditional mathematics classrooms, tasks, discourse, learning environment and analysis of teaching and learning are not necessarily the core dimensions driving the instructional design.

3. **Math Science Partnership (MSP)—**Established under the National Science Foundation Act of 2002 as an effort to respond to growing concerns of too many teachers teaching out of their certification field, not enough students taking advanced courses and too few schools offering challenging curriculum and textbooks (Williams, Pane, Tananis, Olmsted & Ciminillo, 2006).

4. **Math & Science Collaborative (MSC)—**Formed in 1994 as a regional approach in Southwestern Pennsylvania focused on strengthening mathematics and science education by coordinating and focusing resources. The MSC coordinates efforts and focuses resources "through innovative, evidence-based, regional approaches to the teaching and learning of mathematics and science from preschool through university" (Math & Science Collaborative, 2012). The MSC is led by the Allegheny Intermediate Unit and is supported by federal and state grants and numerous local foundations (Math & Science Collaborative, 2012). The MSP opportunities of Southwestern Pennsylvania were provided through the work of the MSC.

5. **Teacher Leadership Academy (TLA)**—As part of the Southwestern PA MSP, the TLAs consisted of leadership development for selected teachers, grouped by discipline (science and mathematics) and grade band levels. In the academies, trainings occurred over multiple years. The Teacher Leader participants were then expected to return to their districts and develop "communities of learning" sharing what they learned in academies with their fellow colleagues within their own buildings (Tananis, 2005). TLAs were offered at both the elementary and secondary levels. For the purposes of this study, the term TLA will refer to the Secondary Mathematics TLA.

6. **<u>On-Site Academy (OSA)</u>**—As part of the Southwestern PA MSP, these occurred as a result of selected teachers participating in the Teacher Leadership Academies. After a teacher's participation, then the Teacher Leader conducted the same professional development experience in the TLA with their fellow colleagues.

7. **<u>Leadership Action Team (LAT)</u>—**As a component of the Southwestern PA MSP, the teams were composed of district administrators and mathematics and science teachers from each level (elementary, middle and high school). In the LATs, each team assessed strengths and weaknesses of its organization and developed an action plan for improvement. In addition, the teams determined teachers and administrators that participated in the select MSP activities. The LATs met four times per year, with two of these meetings occurring at the *Network Connections* Conference.

8. **<u>Institution of Higher Education (IHE)</u>**—As part of the Southwestern PA MSP, higher educational institutions partnered with K-12 educational systems. For the Southwestern PA MSP, the four IHEs were Chatham University, Carlow University, Robert Morris University and St. Vincent College. Each is a private institution.

9. **<u>MSP Logic Model</u>—**To address the Southwestern PA's MSP's theory of action and its long-term goals, a logic model was developed that described the theory of action of the MSP project. This logic model also highlighted the intervention strategies that the MSP utilized to meet its long-term goals. Further, it depicted the MSP's inputs, intervention strategies and outputs. It also identified the theory of change related to short-term, mid-term and long-term outcomes

relative to the reform effort of increased capacity for change in the K-20 educational continuum. This K-20 includes higher education.

10. **<u>Intermediate Unit (IU)</u>**—Intermediate Units were established in Pennsylvania in 1970 by the General Assembly passing Act 102. As a result, 29 Intermediate Units were created and mandated:

> to create a broad program of educational services to be offered to public and nonpublic schools, including curriculum development and instructional improvement services; educational planning services; instructional materials services; continuing professional education services; pupil personnel services; State and federal agency liaison services; and management services. (General Assembly of the Commonwealth of Pennsylvania, 1997, p. 1)

2.0 REVIEW OF LITERATURE

For the past twenty years, there have been an abundant number of resources devoted to increasing mathematical achievement in the United States. Many of the resources have been dedicated to implementing standards-based mathematical classroom practices. In 1989, the National Council of Teachers of Mathematics (NTCM) published the *Curriculum and Evaluation Standards for School Mathematics*. This was NCTM's first attempt at broadly defining the concepts students encounter during their mathematics education; moreover, "NCTM led other subject-matter areas first by producing content standards for Grades K-12 mathematics" (Ferrini-Mundy & Martin, 2007, p. 395). This framework and NCTM's subsequent publications, such as the *Professional Standards for Teaching Mathematics*, painted the landscape for what is currently referred to as standards-based mathematics instruction.

2.1 CONTEXT OF STANDARDS MOVEMENT

Occurring almost simultaneously with NCTM's publications were the mathematical assessments of the Trends in International Math and Science Study (TIMSS) and the National Assessment of Educational Progress (NAEP). In 1995, the first administration of what is currently referred to as the TIMSS occurred. The scores of U.S. fourth, eighth and twelfth grade students on the

TIMSS assessments were bleak compared to students in several different countries. Many countries outperformed U.S. students with a similar pattern of performance occurring consistently across different grade levels. The combination of the poor performance of U.S. students in comparison to international counterparts along with the number of students scoring at the basic level on the NAEP assessment proved to be concerning. This created both an educational and political sense of urgency to increase the mathematical performance of U.S. students.

The coupling of NCTM's attempt to define mathematical standards and the performance of students on the TIMSS and NAEP assessments served as a strong impetus for the reform of mathematics instruction in the U.S. Since 1989, NCTM has published subsequent, revised mathematical standards that argue for mathematical reform while articulating and advocating instructional practices portraying the ideas called upon by the *Professional Standards for Teaching Mathematics*. National resources in the U.S. have been committed to increasing mathematical achievement of students. Even recently, national educational initiatives such as Race to the Top have validated school districts, which have committed to increasing Science, Technology, Engineering and Mathematics (STEM) initiatives by designating these school districts with "competitive preference priority" in their grant applications (Robelen, 2010).

At the same time, the political landscape of education remains a context of accountability. Described in the federal mandate of *No Child Left Behind* (2001), school districts are required to meet federal reporting accountability measures in the areas of mathematics and reading. Schools and districts must comply with meeting these federally established thresholds, and if schools and districts are unable to do so, then they "must implement 'scientifically based' instructional programs to raise the test scores of their students" (Ellis, 2008, p. 1340). Schools and districts unable to achieve this are also allotted mandates and sanctions, such as district-provided student tutoring or the reassignment of the district's governance to the state to assist with compliance (Ellis, 2008). Consequently, the mathematical performance of U.S. students continues to be scrutinized and compared both nationally and internationally. As a result, a sense of urgency in increasing the mathematical performance of students continues to exist.

The convergence of contrasting political and educational landscapes has bolstered the argument for current mathematical reform efforts in the U.S. With current reform efforts, mathematical curricula have been revised and rewritten, and many states have adopted and revised their curricula to reflect the NCTM standards. Furthermore, in Pennsylvania the recent crafting of the PA Core Standards is causing additional changes in curriculum and teacher practice. The PA Core Standards are derived from the Common Core Standards which require students to develop a deeper understanding of mathematical concepts while also demonstrating the Standards for Mathematical Practice. Consequently, mathematical instructional pedagogy continues to be studied, suggested and redefined. Because teacher knowledge of subject matter, student learning and teaching methods are important elements of teacher effectiveness, professional development opportunities for mathematics teachers and administrators continue to be hot topics for educational research (Loucks-Horsley & Matsumoto, 1999).

2.1.1 "MATH WARS"

With the transformation of the purpose of public education, the view of what constitutes effective mathematics instruction has changed drastically over the last century. During the late nineteenth and the early part of the twentieth century, the role and purpose of public education and schools have changed substantially. During the 1890s, the purpose of elementary schools was to educate the masses (Schoenfeld, 2004). High school education opportunities existed only for a very select group of students with fewer than four percent of students in the U.S. both completing and graduating from high school (Schoenfeld, 2004).

During this time period, the role of mathematics instruction served a vastly different purpose as compared to the aims of mathematics instruction of today. At this time, elementary mathematics instruction was designed to provide very basic instruction in the area of arithmetic. However, a different expectation existed for mathematics education at the high school level. For those few students who were able to pursue high school, many students were expected to study higher-level courses such as Algebra, Geometry and Physics (Schoenfeld, 2004).

Although there has been debate regarding mathematics instruction during the past twenty years, controversy over mathematics instruction actually existed as early as the 1940s. With a national landscape permeating the images and ideas of war, the purpose of mathematics education was centered on the importance of preparation for the military and the economy (Schoenfeld, 2004). According to Schoenfeld (2004), there was outrage expressed by the United States Army as it had to issue arithmetic training to its soldiers; these soldiers were not able to complete the arithmetic tasks needed for “bookkeeping and gunnery” (Schoenfeld, 2004). Although the concerns were addressed somewhat in mathematics instruction, little of the mathematical curriculum was affected as a result of the concerns. National concerns of the lack of mathematical skills of U.S. students continued to emerge.

During World War II, there was heightened awareness with the developing and upcoming technological age. As a response, the National Council of Teachers of Mathematics (NCTM) appointed the Commission on Postwar Plans to develop recommendations for mathematics curriculum (Herrera & Owens, 2001). The overarching goal of this time was “to establish the United States as a world leader and to continue the technological development that they had begun during the crisis of war” (Herrera & Owens, 2001, p. 84).

With the Soviet Union’s successful launch of Sputnik in 1957, a national reaction of the allotment of resources designated to promote mathematics and science education was prompted. The U.S. was determined to maintain its position of power and innovation with both technology and military power (Herrera & Owens, 2001). With assistance from the National Science Foundation (NSF), the response was the formation and revision of mathematics curriculum to include “modern” content that included “aspects of set theory, modular arithmetic, and symbolic logic” (Schoenfeld, 2004, p. 257). This new curriculum constituted the “new math” that echoed the priorities and concerns of the 1960s.

This new math led to many parents and teachers feeling “disenfranchised” by the new curriculum. The pronounced dissatisfactions of such groups led to the “back to the basics” movement of the 1970s and 1980s, which “focused largely on skills and procedures” (Schoenfeld, 2004, p. 258). More abstract concepts were abandoned. Herrera and Owens (2001) explained:

> Socratic dialogue and pedagogical approaches of discovery were relinquished for those backed by principles of behavioral psychology. Lesson objectives were stated in terms of observable measurable behaviors. (p. 87)

In the 1980s, mathematical performance of U.S. students once again became a national concern as students were unable to problem solve. Even though the back to the basic mathematics curriculum had emphasized basic arithmetic skills, there was still no improvement, as demonstrated by standardized testing in this area (Schoenfeld, 2004).

Furthermore, in 1980, the NCTM published *An Agenda for Action*, which urged for a mathematical curriculum that claimed for problem solving to be at the core of mathematics. At this time, the idea of problem solving was utilized in classroom instruction; however, it was superficial in nature (Schoenfeld, 2004). Problem solving often referred to performing computational type tasks which were simply expressed in a verbal context. Such problem-solving tasks did not require higher order thinking, and as a result of the publication of *An Agenda for Action*, publishers revised textbooks to include problem solving editions of textbooks (Schoenfeld, 2004). Although there was an emphasis on problem solving, “the changes were trivial, typically consisting of insertions of problem-solving sections (a page or two) at the end of chapters that were otherwise essentially unchanged” (Schoenfeld, 2004, p. 259).

2.1.2 VIEWS OF INSTRUCTION

During the years following World War II, educational practices were greatly influenced by the behaviorist view of learning. Behaviorists view the responses of learning and thinking as products of stimulus-response associations with the student acquiring basic skills that allow for the higher order skill of thinking (Greeno et al., 1997). Behaviorists focus on the actions related to thinking. In fact, many educational practices in the U.S. conveyed this behaviorist viewpoint. Greeno et al. (1997) described:

> much educational practice became committed to organizing curricula and assessments according to behavioral objectives, based on analyses of complex skills into their components, and with instruction organized to ensure that students could master the prerequisites of material they were expected to learn. (p. 91)

When translated to mathematics instruction, behaviorists view the learning of mathematics from two different assumptions. One assumption believes the learning of mathematics occurs as a result of a student's individual talent and motivation (Greeno et al., 1997). For a student who encounters difficulty with mathematical thinking, behaviorists assume this is due to a lack of talent or motivation to engage in thinking about complicated tasks (Greeno et al., 1997).

The second assumption of thinking "depends on a general skill, as well as on accumulated basic knowledge, the cause of most students' success in thinking is their lack of acquiring this skill" (Greeno et al., 1997, p. 91). This second assumption translates into classroom settings with teachers developing their students' skills in order to encourage students to test out ideas and develop techniques to discover or restate problems rather than selecting methods of solutions from a solution bank of which they have previously solved specific kinds of problems (Greeno et al., 1997).

Significant contributions to the theories of mathematics reform and standards-based mathematics instruction derive from both constructivism and social constructivism. Proponents of standards-based mathematics have embraced the discourse of constructivist psychological theorists. For example, Jean Piaget's stages of cognitive development have influenced elementary mathematics education. Specifically, Piaget's stages of conservation and reliability impacted mathematics at the elementary level (Herrera & Owens, 2001). Piaget's work perpetuated the notion of using concrete examples and physical manipulatives to portray mathematical concepts in order to increase a student's mathematical understanding of a concept; moreover, Piaget believed students built upon prior knowledge to make meaning of new knowledge (Herrera & Owens, 2001).

Although Piaget's view of constructivism advocates for learners to learn in developmentally appropriate steps, Vygotsky's view of constructivism is a "non-developmentary view of education whereby a child's intellectual personality and socio-moral knowledge is 'constructed' by students internalizing concepts through *self-discovery*" (Jaramillo, 1996, p. 135). This translates into a classroom where students learn through their interactions with peers, teachers, and manipulatives in their contextual setting (Jaramillo, 1996). Such theories redefined the notion of student learning; consequently, this affected mathematics education by reshaping beliefs of how students construct meaning of mathematical knowledge.

The combined work of Vygotsky and Piaget contributed to the notion of social constructivism where knowledge is framed through the experience and meaning making of students. This shift in thinking about knowledge construction provided the basis for how NCTM framed mathematical knowledge. The *Curriculum and Evaluation Standards for School Mathematics* (1989) and *National Science Education Standards* (1996) promoted the notion that "all students be afforded the opportunity to learn mathematics and science through inquiry-based experiences" (Huffman, Thomas & Lawrenz, 2008, p. 138). The notion of inquiry-based learning of mathematics and science manifests from both Vygotsky's and Piaget's social views of learning. Huffman, Thomas and Lawrenz (2008) identified that within inquiry-based experiences:

> students are encouraged to collaboratively interpret information in light of existing knowledge, and actively construct and reconstruct understandings, rather than receive information from an authoritative source such as the teacher. (p. 138)

The American psychologist Jerome Bruner also contributed to the discourse of standards-based mathematics education. Bruner believed student learning experience should be comprised of "investigation and discovery rather than being told the relevant concepts and expected to practice the skills" (Herrera & Owens, 2001, p. 85). Emerging views of learning supported the philosophy of standards-based mathematics instruction as the social construction of making meaning of mathematical knowledge rather than repetition of rote procedures.

2.1.3 STANDARDS-BASED MATHEMATICS INSTRUCTION

With emerging different learning theories, what constitutes effective mathematics instruction has been reshaped and redefined to the current notion of standards-based mathematics. As defined in Chapter 1, standards-based mathematics instruction portrays students as active agents of their own meaning making. In this type of mathematics, students are "actively involved constructing their own mathematical knowledge, not memorizing the steps of a teacher-directed algorithm or endlessly practicing a litany of procedures" (Alsup, 2005, p. 3). Teachers emphasize active learning as students engage in interactive and problem-centered tasks (Alsup, 2005). Students are provided with opportunities to act on their environments in order to construct their own knowledge (Brown, 2003). In these types of classroom experiences, students are able to "do mathematics." Hiebert (2007) described doing mathematics as:

> engaging in the intellectual processes that are essential to mathematics: solving problems through reasoning, conjecturing, inferring, deducing, justifying, and so on. These processes are valued not only because they produce a certain kind of knowledge but also because an ability to engage in them is important in itself. (p. 13)

Throughout the course of this study, the term standards-based mathematics refers to mathematics instruction reflective of these characteristics.

In standards-based mathematics instruction, the role of the teacher transforms. The teacher is viewed as a facilitator of learning whose role is to direct experiences and construction of the acquisition of student knowledge. The classroom is student-centered with students accruing a considerable degree of direction and responsibility for both what is taught and how it is learned (Cuban, 2001). As a facilitator, the teacher designs the learning experiences of her students and orchestrates it in such a way to guide students to discover meaning of new concepts (Brown, 2003). The experiences focus on "real-world, real-life information, not on minute and esoteric concepts and skills that have little practical use in everyday life" (Brown, 2003, p. 102).

Beyond acting as facilitator in standards-based mathematics, teachers provide contextually relevant experiences that anchor their students' learning. The contextually relevant experiences are authentic and require students to apply concepts to problems they encounter (Brown, 2003). Assessments and activities occurring in standards-based classrooms do not disconnect the concepts and skills utilized in the classroom from the students' own experiences. Rather, classroom experiences build upon and connect mathematical concepts to such experiences.

2.1.3.1 Professional Standards for Teaching Mathematics

In 1983, the National Committee on Excellence in Education published *A Nation at Risk* detailing the current status of the nation's educational affairs. This "further document[ed] the failure of post-Sputnik efforts to close the gap in math and science achievement between the United States and other industrialized nations" (Hofmeister, 2004, p. 5). The summation of these different events in conjunction with the performance of U.S. students on international assessments such as the TIMSS provided the catalyst for the 1989 NCTM publication of

Curriculum and Evaluation Standards for School Mathematics, “a document intended to be a multi-voiced statement reflecting the varied composition of the organization [NCTM] and to produce a consensus broadly acceptable to the mathematics community” (Herrera & Owens, 2001, p. 89). The *Standards* served as an attempt to define the standards for mathematics instruction and education. In 1989, NCTM established a commission to produce a set of *Professional Standards for Teaching Mathematics* to serve as a companion to the newly released *Curriculum and Evaluation Standards* (National Council of Teachers of Mathematics, 1991). Consequently, in March of 1991 NCTM published the *Professional Standards for Teaching Mathematics* designed to identify standards of instructional practice for mathematics. The National Council of Teachers of Mathematics (1991) explained:

> the goal of this second set of standards was to provide guidance to those involved in changing mathematics teaching. Together, these two sets of standards are part of NCTM’s long-term commitment to provide direction for the reform of school mathematics. (p. 2)

The *NCTM Standards* advocated changes in both content and pedagogy for mathematics teachers (Herrera & Owens, 2001). The *Professional Standards for Teaching Mathematics* identified guidelines for mathematics instruction and provided examples of instructional strategies identified as necessary for students’ mathematical thinking.

NCTM’s *Professional Standards for Teaching Mathematics* (1991) addressed five instructional shifts for mathematics classrooms. The shifts include transforming the classroom into a mathematical community, having students move toward logic and mathematical evidence as verification, emphasizing mathematical reasoning, emphasizing conjecturing, inventing and problem solving, and connecting mathematics to applications (National Council of Teachers of Mathematics, 1991). In the *Professional Standards for Teaching Mathematics*, six standards are identified as related to the Standards for Teaching Mathematics: worthwhile mathematical tasks, the teacher's role in mathematical discourse, the student's role in mathematical discourse, tools for enhancing mathematical discourse, the learning environment and the analysis of teaching and learning (National Council of Teachers of Mathematics, 1991). Each of the six standards reflects core dimensions which are "major arenas of teachers' work that are logically central to shaping what goes on in mathematics classes" (National Council of Teachers of Mathematics, 1991). The dimensions include mathematical tasks, discourse, environment and analysis.

The first dimension, mathematical tasks, refers to the projects, constructions, applications and problems in which students engage (National Council of Teachers of Mathematics, 2001). According to the National Council of Teachers of Mathematics (2001), "students should encounter, develop and use mathematical ideas and skills in the context of genuine problems and situations" (p. 19). Such tasks situate the learning within the students' mathematical development while providing an opportunity for students to make authentic connections (National Council of Teachers of Mathematics, 2001). The dimension of discourse refers to how students represent, think, discuss and argue; moreover, it reflects values as to what constitutes legitimate knowledge in the classroom (National Council of Teachers of Mathematics, 2001). As indicated in the *Professional Standards for Teaching Mathematics* (2001), this "requires an environment in which everyone's thinking is respected and in which reasoning and arguing about mathematical meanings is the norm" (National Council of Teachers of Mathematics). Consequently, the role of teachers is to orchestrate such classroom norms and provide students with the opportunity to discuss, write and reason around mathematical concepts.

The learning environment provides a setting where deep mathematical thinking and exploration can occur (National Council of Teachers of Mathematics, 2001). It also includes the use of materials and space, and it represents the context for which both tasks and discourse are situated (National Council of Teachers of Mathematics, 2001). The final dimension, analysis, refers to systematic reflection of instruction (National Council of Teachers of Mathematics, 2001). When teachers are engaged in systemic reflection, they are using information to revise their instructional plans, inform the mathematical tasks they are selecting and design their plans to facilitate classroom discourse (National Council of Teachers of Mathematics, 2001). Each of the Standards for Teaching Mathematics reflects one of these dimensions.

With the publication of *NCTM's Standards*, "the reform has had an impact on school mathematics to the extent that most states have rewritten their frameworks to align with the *Standards* in language, grade level demarcations, and goals" (Herrera & Owens, 2001, p.90). The *NCTM Standards* also emphasized a shift in mathematical thinking where fostering conceptual understanding is favored over procedural thinking. With the adoption of the Common Core Standards, states again are revisiting and revising their curriculum frameworks currently to address both conceptual understanding and procedural fluency.

2.1.3.2 Common Core State Standards

In 2010, the Common Core State Standards (CCSS) emerged. For mathematics, the CCSS were developed using: scholarly research, surveys of skills of college and career ready students, assessment data that measured college and career ready performance, comparisons to standards of both high-performing states and nations, findings from the TIMSS study and additional studies that indicated that the traditional U.S. mathematics curriculum needed to become more coherent and focused (CCSO, 2013). Forty-five states have adopted the CCSO. In July 2010, Pennsylvania adopted the Common Core Standards; however, PA decided to craft its own set of PA Core Standards (PAC) based upon the national Common Core Standards for both English Language Arts and Mathematics. The PA Core Standards reflect the image of the PA Academic Standards. According to the Pennsylvania Department of Education's SAS website (2013), "these new standards mirror the content and rigor of Common Core, but reflect the organization and design of the PA Academic Standards."

As a result of more rigorous standards, school districts are currently in the process of revising their curriculum to reflect the PAC. The Common Core/PAC narrow mathematical content by grade levels in order to provide more focus. These new standards expect students to gain a greater conceptual understanding and mastery of content. In addition, the CCSS and PAC reflect more than simply content standards as did the former Pennsylvania Academic Standards; they also reflect process standards. The Standards for Mathematical Practice, which are part of the PAC, focus upon the process of how students engage in mathematics. Consequently, in addition to content standards, process standards now need to be articulated in the mathematics curriculum and reflected in classroom instruction. For some school districts, this requires revising both curriculum and instructional practices.

2.1.4 SUSTAINING REFORM

As schools are revising and refining curriculum and instructional practices in light of the new standards, it is important to consider school characteristics leading to the institutionalization and sustainability of change efforts in general. According to Fullan (2000), depending on a school's size, it takes approximately six years for a successful change to affect student performance. Although reform efforts may be instituted in schools, many such efforts lead to "strong adoption and implementation, but not strong institutionalization;" moreover, reform efforts only truly manifest themselves in a small amount of schools (Fullan, 2000, p. 581). To address issues of institutionalization and sustainability of change efforts, it is important to consider teachers as key players in instructional reform efforts (Supovitz, Mayer & Kahle, 2000).

As a result, heavily involving teachers in reform efforts is preferred; this may even involve reconstructing teacher beliefs. Often reform efforts, such as mathematics reform and standards-based instruction, require teachers learning to do something in a new way, which in turn requires social learning. Fullan (2007) explained:

> new meanings, new behaviors, new skills and new beliefs depend significantly on whether teachers are working as isolated individuals or are exchanging ideas, support and positive feelings about their work. The quality of working relationships among teachers is strongly related to implementation. (p. 97)

Consequently, professional development allowing for collaboration and exchange may be linked to the implementation and institutionalization of reform.

Fullan (2000) identified three different stories of a school that may also impact reform efforts: inside story, inside-out, and outside-in. The inside story refers to the dynamics occurring within the school during the reform. For example, the institution and utilization of Professional Learning Communities (PLCs) is an example of "reculturing" that occurs within schools (Fullan, 2000). According to Fullan (2000), when reculturing happens "deeper changes in both culture and structure can be accomplished" (p. 582). This reculturing is what allows for the deeper changes of reform to root within an organization.

The inside-out story refers to the forces outside of the school contributing to the implementation of reform efforts; outside forces include parents, community, technology, corporate connections, and policies (Fullan, 2000). With ever increasing state and federal accountability policies, outside forces are consistently confronting teachers in their daily work (Fullan, 2000). Schools that are selective and are able to establish connections amongst the different forces are more likely to institute reform efforts.

According to Fullan (2000), the outside-in story refers to elements of external reform infrastructure. This refers to providing school site based emphasis, building local capacity, rigorous external accountability systems and stimulation of innovation (Fullan, 2000). Providing school site based emphasis and building local capacity provides more leadership opportunities into the hands of teachers. According to Anderson (1996), "teachers within a department or a school are given increased freedom and responsibility for making curricular decisions. This downward shift in power extends to students as well; teachers give students the freedom—and encouragement—to engage in self-directed learning" (p. 45-46). Building the capacity of teachers supports the implementation of the reform; however, this alone does not necessarily lead to reform oriented changes to actually occur in instruction (Elmore, 1995). Coupling teacher empowerment with an instructional focus is more likely to lead to pedagogical changes influenced by reform efforts. As Elmore (1995) indicates, "when the values and norms of the school focused attention on instruction and teachers took responsibility for student performance, teacher empowerment seemed to lead to significant changes in pedagogy and changes in pedagogy seemed related to changes in student learning" (p. 25). As a result, teachers continue to remain key players of reform efforts.

Sustaining implementation of a reform and its impact on instruction is another important consideration. The reform's institutionalization may depend on if the reform has become embedded into the school's structure (policies, budgets), has generated a critical mass of both teachers and administrators that are skilled and committed to the reform, and procedures have been established for providing continual assistance especially in the training of new faculty and staff (Fullan, 2007). Even if a reform's implementation efforts were successful, "problems of continuation, even in the face of initial successful implementation, persist to this day" (Fullan, 2007, p. 102).

Although initial reform implementation efforts may be successful, institutionalization and sustainability of such reform requires deeper, cultural changes within schools and within teachers. Elmore (1995) indicated:

> one implication of this finding for reformers is that reforms might focus first on changing norms, knowledge, and skills at the individual and organizational level before the focus on changing structure. That is, teachers might actually learn to teach differently and develop shared expectations and beliefs about what good teaching is, and then invent the organizational structures that go with those shared skills, expectations, and beliefs. (p. 26)

As a result, professional development opportunities are desired that address such changes in beliefs and pedagogy as related to reform efforts.

2.1.5 TIMSS

With the bleak performance of U.S. students on the TIMSS assessment during the mid-1990s, a sense of urgency emerged to improve the mathematical performance of students. This landscape caused educators to identify important skills and practices in mathematics to be addressed in the standards. The NCTM *Standards* called for more performance-based and authentic assessments. However, in the midst of this standards-based movement, performance on the 1999 TIMSS assessment was still disappointing. Although this movement focused on providing authentic, problem solving and performance based tasks for students, “U.S. performance was at or below the international average on all Performance Assessment tasks, and U.S students showed less clear signs of strengths and weaknesses than did students in other countries” (Jakwerth, 1999, p. 278). According to Jakwerth (1999), the TIMSS results indicated U.S. students performed worse than economic competitors, and in 1999 the National Center for Education Statistics reported the scores of the U.S. eighth graders in mathematics ranked 19th with 14 countries significantly outperforming the U.S.

In 2003, U.S. eighth grade scores on the TIMSS assessment ranked 15th with nine countries scoring significantly higher. In 2007, the performance of U.S. eighth graders ranked ninth in comparison to other countries with five countries scoring significantly higher (National Center for Education Statistics, 2013). Although there was some improvement of U.S. performance during this time, the countries of Singapore, Korea, Chinese Taipei, Hong Kong and Japan consistently ranked as the highest performing countries in mathematics during the 1999, 2003 and 2007 administration (National Center for Education Statistics, 2013).

During the 1993-94 administration of the TIMSS assessment, a video component of the study was also conducted. This piece of the study performed by Hiebert and Stigler (2000) identified differences in how eighth grade mathematics was taught in U.S., German and Japanese classrooms. The study also examined reform effects on the classroom practices of teachers.

During the 1994-1995 school year, Hiebert and Stigler (2000) identified most U.S. teachers indicated they were aware of current ideas of teaching and learning of mathematics. More teachers in the U.S. claimed to be aware of the current mathematical trends than teachers in Germany or Japan; U.S. teachers also identified their current knowledge of these new practices stemmed from workshops, conferences or school based programs they had attended (Hiebert & Stigler, 2000).

In the video study 59% of U.S. teachers reported the NCTM organization served as their primary source of knowledge for new ways of learning mathematics (Hiebert & Stigler, 2000). After watching the videotapes of their classrooms, teachers were interviewed, and seventy percent of U.S. teachers videotaped indicated a “fair amount” of standards-based ideas had been reflective in their lessons. The percentage reported by U.S. teachers was higher than German and Japanese teachers (Hiebert & Stigler, 2000). Although the U.S. teachers claimed to be the most knowledgeable in current standards-based mathematical pedagogy, this was not validated in the classroom observations of the study.

When U.S. teachers were asked to connect specific aspects of their lessons to the ideas of standards-based practices, teachers typically described superficial ideas. For example, the majority (approximately two-thirds) of the teachers classified their activities into three categories: real-world and/or hands-on activities; cooperative learning and mathematical thinking and problem solving (Hiebert & Stigler, 2000). These elements reflected an organizational change of structure which “means that more than two-thirds of the teachers focused on activities or organizational features of the classrooms, features that can be implemented easily without altering the way in which students and teachers *do* mathematics” (Hiebert & Stigler, 2000, p. 6). Organizational changes were occurring in U.S. classrooms; however, how children actually discovered and learned mathematics remained essentially the same.

The subsequent 1999 video study was expanded to include the U.S, Australia, the Czech Republic, Hong Kong, Japan, the Netherlands, and Switzerland. The expansion to these new countries occurred because each significantly outperformed the U.S. on the 1995 TIMSS assessment (Stigler & Hiebert, 2004). A significant finding identified in this video study included how high-performing countries such as Hong Kong and Japan implemented standards-based notions such as “making connections” with problems in their classrooms. In these countries students were presented with problems requiring them to make connections; moreover, the problems were presented as such and students completed them as originally presented. When the same problems were presented in U.S. classrooms, “the U.S. teachers turned most of the problems into procedural exercises or just supplied the students with answers to the problems” (Stigler & Hiebert, 2004, p. 15). The higher order thinking required to solve the problems was not evident in U.S. classrooms.

Moreover, in U.S. eighth grade classrooms, students spent much of their time practicing procedures without engaging in the deliberate study of mathematical concepts (Stigler, 2004). Again, the findings reinforce the need to move beyond implementation of superficially standards-based implementation in U.S. classrooms. Even though requiring students to make connections is a standards-based idea, the substance of the standards-based instruction was not maintained in U.S. classrooms.

With such scrutiny surrounding the U.S. performance on the TIMSS assessment, a heightened interest existed in the educational practices of high performing countries like Singapore and Japan who continuously outperform their international counterparts. The videotape study of the TIMSS assessment identified and characterized instructional practices of Japan that fostered mathematics success. Specifically, the instructional practices observed in Japanese classrooms aligned more closely to the ideas promoted by NCTM. According to Eugene Geist (2000), “the Japanese do a much better job of treating their students like mathematicians and implementing the ideas behind the NCTM’s Standards” (p. 181). In contrast in U.S. classrooms, the videotaped component of the TIMSS study described classrooms as predominantly teacher-centered where “the teachers did most of the mental work, such as explaining and modeling skills and concepts or providing answers and solutions” (Martinez, 2001, pp. 114-115). In Japan, classroom dynamics were student-centered with lessons that required students to derive the concept through their own struggles with problems (Martinez, 2001).

Although the Japanese teachers engage their students in mathematics, it is necessary to mention the existence of cultural differences that in both U.S. and Japanese classrooms and overall educational structures. It is not realistic to suggest that U.S. teachers could implement the classroom practices of Japan and achieve exactly the same results. Without addressing cultural differences and how they affect teaching and learning, it is irresponsible to believe these classroom practices could be replicated identically into U.S. classrooms. However, it is beneficial to analyze the teaching practices through the lens of standards-based instruction to identify characteristics of the practices and how they may be implemented in U.S. classrooms.

In addition to the comparisons of teaching practices, there became a heightened interest of the professional development structures of Japanese teachers. For example, Japanese teachers participated in lesson study where teachers meet weekly in small groups for one hour to plan, implement, evaluate and revise lessons collaboratively (Stigler & Hiebert, 1997). Teachers create lessons, and teach lessons with other teachers observing. This process may occur for years as teachers continuously improve and refine their bank of lessons. Furthermore, Japanese teachers share the lessons with not only colleagues in their school but also with colleagues from other schools. Teachers participating in lesson study embark upon this process as a journey that respects the cultural complexity of teaching; moreover, they do so in such a way which enables them to focus on contexts in which all relevant parts of the teaching process are naturally embedded (Hiebert & Stigler, 2000).

Recently, the adaptation of lesson study as a professional development tool for U.S. teachers has increased. Mathematics teachers are encouraged to engage in collaboration with colleagues and peers regarding mathematics instruction. Different institutions have offered lesson study protocols to assist with participation in the lesson study process. Stigler & Hiebert (1997) explained:

> only when teachers are allowed to see themselves as members of a group, collectively and directly improving their professional practice by improving pedagogy and curricula and improving students' opportunities to learn, will we be on the road to developing a true profession of teaching. (p. 12)

As a result, lesson study has been a professional development tool highly valued within the mathematics community; however, the current cultural organizational structures in U.S. educational systems are not necessarily conductive for the structure of this professional practice.

2.1.6 PRESENT DAY

With the authorization of *No Child Left Behind* (2001), high stakes testing and accountability have been the educational context for well over a decade. School districts are expected to meet federal accountability targets in mathematics, as demonstrated through high stakes testing. Further, *NCLB* outlines different sanctions to be bestowed upon schools who do not meet the targets or who do not show growth in their various subgroups.

The pedagogical outcomes of standards-based mathematics instruction as defined by NCTM have not necessarily been reflected in the accountability measures of *NCLB*. According to Herrera & Owens (2001), “high-stakes testing is often not aligned with the Standards, which further raises frustration as parents and teachers grow increasingly concerned about student performance on these tests” (p. 90). In fact, there has been significant criticism of teachers aligning their classroom instruction to the content of high stakes tests rather than designing instruction targeted to support the ideas of standards-based instruction. According to Ellis (2008), high stakes testing supports the notion that “mathematics is something to be put into students’ heads, apart from their lived experiences and daily lives” (p. 1331). This contradicts the philosophy behind standards-based instruction calling for students to “view mathematics not as disconnected external facts and procedures but as meaningfully connected sets of ideas about which students could develop personal understandings” (Ellis, 2008, pp. 1349-1350).

Critics of *NCLB* argue this further advances the separation of high performing and low performing students with regard to mathematics. Through *NCLB*, “teachers would not only be justified but also compelled to provide instruction to ‘lower level’ students that leads to increased scores” (Ellis, 2008, p. 1342). The performance levels of different groups of students may determine the extent of the support and interventions students receive from their teacher. Critics also argue the effects of *NCLB* on the mathematics curricula in general. When pressure exists to increase scores on high stakes assessments, then schools and districts may reshape the curriculum to represent the limited content being assessed on the assessment instrument (Ellis, 2008). In Pennsylvania, this typically translates into a curriculum composed of PA Eligible Content. Since typical standardized assessments measure a student’s mastery of basic skills, they do not necessarily capture the standards that NCTM argues as the backbone of effective mathematics instruction. Moreover, with Pennsylvania's adoption of the PA Core Standards, school districts are now in the process of revising their mathematics curriculum again. Within the PAC, much emphasis is placed on developing a focused, coherent and rigorous curriculum for which teachers will be accountable. Accompanying this is also new assessments being designed that will capture higher levels of rigor as reflected in the PA Core.

Over the past decades, there has been much debate as to what constitutes effective mathematics instruction, with the greatest momentum occurring with the release of the NCTM *Standards*. Current efforts of standards-based mathematics promote deep mathematical understandings where students make sense of mathematics through their own experiences. Communication of mathematics is valued, and the role of the teacher is to serve as a facilitator who works to create experiences with which students engage. Students are encouraged to foster their understandings of mathematical concepts versus replicating mathematical procedures, and students are encouraged to utilize creativity to solve problems by trying out different methods. The current *NCLB* act with its emphasis on high stakes testing suppresses the essence that current standards-based instruction represents. As educators working in the current political landscape of high stakes accountability, it may be difficult to implement and sustain standards-based practices as called upon by NCTM when they are not captured by the current assessment system; however, the PAC and its new assessment system may help to establish standards-based instructional practices as they were intended to be as the focal point of mathematics curriculum.

2.2 PROFESSIONAL DEVELOPMENT

With the implementation of more rigorous standards, there is a need to consider the types of professional development experiences being provided to teachers. With the Standards for Mathematical Practice, teachers are being asked to deliver mathematics instruction in ways very different than they may have experienced as students. This translates into considerable shifts occurring with both their content knowledge and pedagogical content knowledge; moreover, "teachers need to be skilled in how to make decisions about what students know, what they need to know, and how they can be helped to gain that knowledge—and the knowledge to help their students do so" (Loucks-Horsley & Matsumoto, 1999, p. 261). For the shifts to occur and be sustained, intensive professional development is needed. The NCTM's *Principles and Standards* argue teachers possess a deep understanding of the mathematics they teach in order to use that knowledge to flexibly design and respond to teaching tasks (Mewborn, 2007). The PA Core Standards also require this. Attending to these changes requires addressing both teachers' content and pedagogical content knowledge.

Despite the efforts of reformers to prepare teachers to engage in this type of instruction, "classroom practice remains largely unchanged" due to inservice teachers' understandings, attitudes, and beliefs of mathematics" (Walker, 2007, p. 113). Given today's educational landscape of high stakes testing and accountability, mathematics teachers may encounter conflicting notions as to the competing expectations of the school, the district and mathematical reform. As teachers are expected to integrate standards-based practices, they must also meet both principal and parent expectations of ensuring their students perform adequately on standardized tests. Typically, in the past, the tests have not captured the scope of the skills promoted by mathematical reform and standards-based instruction.

In addition, the types of mathematical professional development experiences teachers encounter often times may be designed around a curriculum program or package. Professional development such as this "may target organizational or logistical requirements of a curriculum rather than mathematics content or pedagogy aligned with content objectives" (Walker, 2007, p. 114). This type of professional development does not address a teacher's understanding and beliefs about mathematics; consequently, it may change the instructional practices of a teacher from an organizational perspective as opposed to a pedagogical content knowledge perspective. The current structures of professional development experiences provided in the U.S. do not necessarily support the systematic changes of instructional practices standards-based instruction embraces (Hill, 2009).

2.2.1 ROLE OF TEACHER IDENTITY

It is important to consider the construct of a teacher's identity in understanding how teachers participate and utilize professional development (Battey & Franke, 2008). Furthermore, "effective professional development models should respect and address teachers' existing beliefs about mathematics because these affect their instruction" (Walker, 2007, p. 117). Teachers come to participate in professional development experiences with previously constructed identities of what it means to be a mathematics teacher or even a standards-based mathematics teacher; therefore, professional development is "a space for acquiring new knowledge, re-crafting identities, and challenging existing cultural and social practices" (Battey & Franke, 2008, p.

127). The decision as to what new instructional practices will be embedded into their instructional repertoire is linked and influenced by their already constructed identities (Battey & Franke, 2008).

According to Battey and Franke (2008), “a teacher’s identity connects the contexts of the classroom and professional development, and helps the teacher decide how much of the newly learned knowledge and skills are appropriate for students” (pp. 127-128). Attending and providing time and experiences for teachers to reshape their beliefs is an important consideration when providing professional development. However, this is significantly true for professional development that promotes standards-based mathematics instruction.

With standards-based instruction, teachers are asked to teach mathematics in a manner that may contradict their previously constructed identity of what it means to be a mathematics teacher; furthermore learning to teach new standards is difficult and requires time (Loucks-Horsley & Matsumoto, 1999). As Loucks-Horsley and Matsumoto (1999) explained:

> most teachers, even if their beliefs are consonant with the new reforms, must develop new ways of teaching and assessing their work. Fundamental change in practices and beliefs takes time, because there is much to unlearn and much that is complex to learn (p. 261).

When providing opportunities for teachers to change their instructional pedagogy, time is a pivotal element for consideration.

The implementation of standards-based practices requires teachers to possess a deep understanding of mathematics that allows them to respond and attend to student misconceptions while also deepening their conceptual understanding (Walker, 2007). Battey & Franke (2008) indicated:

> we ask teachers to begin to see themselves as learning from their students; as teachers who learn about their students and students' mathematical thinking in ways that change how they participate in interactions with students, how they talk with parents or engage with mathematics. (p. 130)

The implications of this instruction translate into studying how professional development experiences are provided to teachers. This means rethinking how to provide professional development experiences where teachers are able to reconstruct their identity in order to connect and implement new practices in their classrooms. According to Battey & Franke (2008), "practices recommended by reforms often require more of a teacher in terms of facilitating classroom discussions and guiding students to learn with understanding. These reforms require teachers to have a different relationship to practice and content or new identities" (p. 146). Typically, teachers change classroom practice through tinkering where they pick up new techniques and activities and adjust them to fit their own style (Loucks-Horsley & Matsumoto, 1999). However, the notion of tinkering allows teachers to maintain and perpetuate their current beliefs regarding mathematics instruction (Loucks-Horsley & Matsumoto, 1999).

For the implementation of standards-based mathematics instruction, professional development experiences are designed to examine and challenge teacher beliefs in considering the selection of mathematical tasks, the role of discourse (for both students and teacher), the learning environment and the analysis of teaching and learning occurring in the classroom (Loucks-Horsley & Matsumoto, 1999; NTCM, 2001). Contingent upon professional development experiences that spark cognitive dissonance, teachers can develop new knowledge and skills; furthermore, they may begin to shift their identity as to what it means to be a mathematics teacher (Battey & Franke, 2008). According to Loucks-Horsley & Matsumoto

(1999), teachers are provided time and contexts to work at resolving this dissonance while connecting the dissonance resolving activities that are connected to their own classroom work. To achieve this, professional development experiences provide teachers with opportunities to develop new practices aligning to their understandings. As a result, professional development providers consider "how to help teachers reestablish classroom norms that align with their developing identities on what it means to teach and learn mathematics" (Battey & Franke, 2008, p. 146).

2.2.2 PROFESSIONAL DEVELOPMENT IN THE U.S.

In the U.S. current operational and structural practices of professional development affect teachers on a large scale. In fact, professional development is a big business with estimates that professional development may account for anywhere from one to six percent of the district's expenditures; moreover, these do not include professional development funds provided by either states or federal funding (Hill, 2009). Garet, Porter, Desimone, Birman & Yoon (2001) estimated it costs an average of $512 per teacher to provide the types of high-quality professional development experiences that actually affect and impact classroom instruction.

Almost every teacher participates in professional development, as typically required by state teacher certification requirements; however, "most teachers engage in only the minimum professional learning required by their state or district each year" (Hill, 2009, p. 470). The National Center for Education Statistics (NCES) reported "that just over half of respondents to an NCES survey reported spending a day or less in professional development over the past year" (Hill, 2009, p. 470). The low rate of participation in professional development activities suggests teachers participate in professional development requirements to comply with the mandates of state laws (Hill, 2009).

Professional development practices are also scrutinized as to how they transform classroom instructional practices. According to Hill (2009), in a survey of teachers regarding the last three years of their professional development, less than 25% of teachers indicated that the professional development affected their classroom instruction; whereas, “most teachers, in fact, reported that professional development reinforced their existing practices, and a minority reported no effect at all” (p. 471).

In an analysis of the characteristics of effective professional development, Guskey (2003) compared characteristics of professional development from thirteen different organizations: the American Federation of Teachers, Association of Supervision and Curriculum Development, Educational Research Service, Educational Testing Service, Eisenhower Professional Development Program, National Governor’s Association, National Institute for Science Education, National Partnership for Excellence and Accountability in Teaching, National Staff Development Council, and U.S. Department of Education. The characteristics identified varied significantly as different criteria was used to determine effectiveness; furthermore, the characteristics were described as “research-based” although the majority of them did not measure effectiveness in terms of student learning or instructional practices (Guskey, 2003).

Increasing teachers’ content knowledge and pedagogical content knowledge is a critical characteristic of professional development if it is to affect teacher practice (Guskey, 2003). According to Guskey (2003), “helping teachers to understand more deeply the content they teach and the ways students learn that content appears to be a vital dimension of effective professional development” (p. 748). There is a need for professional development to enhance content knowledge since this is linked to student achievement (Walker, 2007). Consequently, in this type of professional development, pedagogical content knowledge is addressed in order to develop effective instructional strategies and practices for teachers (Walker, 2007). Walker (2007) explained the following:

> teachers should know that it is not sufficient to just use pattern blocks as representations of fractions in a lesson and have students complete a worksheet about fractional parts; rather, teachers should know how and why these blocks could be used to develop students' understandings of fractional concepts. (p. 116)

As a result, this type of professional development provides opportunities for teachers to enhance their content knowledge, pedagogical knowledge and pedagogical content knowledge, and it also occurs in the context of schools and classrooms (Walker, 2007). In these experiences, teachers are "active participants in and constructors of the professional development experience so that they can share and analyze their own classroom experiences" (Walker, 2007, p. 117). This provides opportunities for teachers to translate and apply their learning into their classrooms.

In a study conducted by Garet et al. (2001), the authors identified that for professional development to affect student learning, the activity of the professional development opportunity focuses upon content, and the experiences are designed to deepen the teachers' content knowledge. Furthermore, the experiences are constructed to focus on how children learn framed within those content areas. In relation to mathematics, Cohen and Hill (1998) conducted a study of teaching in California and found the following:

> they found that, controlling for the characteristics of students enrolled, average mathematics achievement was higher in schools in which teachers had participated in extensive professional development focusing on specific math content, compared to the

achievement in schools where teachers had not. Participation in professional development focusing on general pedagogy, however, was not related to student achievement. (p. 924)

For mathematics teachers, it is important that professional development opportunities provide teachers with the ability to further expand and strengthen their content knowledge and pedagogical content knowledge within the context of their classrooms.

In a study conducted of middle school math teachers, Brown, Smith and Stein (1996) validated teachers have positive responses to professional development when it is focused on content and is grounded in artifacts of practice (Hill, 2004). In addition, Linda Darling-Hammond (1998) reported connecting professional development to the teachers' work with students, subject matter and teaching methods is a professional development strategy thought to improve teaching practices. As Stein et al. (1999) indicated, "teachers need assistance that focuses on their day-to-day efforts to teach in these new and demanding ways" (p. 239). Such professional development experiences are anchored in a teacher's daily work.

Many of the other characteristics of Gutsky's study stressed the importance of providing sufficient time and resources; however, time is not necessarily related to improvements in student learning (Guskey, 2003). Time is important; however, "it's clear that the time must be well organized, carefully structured and purposefully directed" (Guskey, 2003, p. 748). In addition, professional development is ongoing and sustained. Garet et al. (2001) stated the following:

first, longer activities are more likely to provide an opportunity for an in-depth discussion of content, student conceptions and misconceptions, and pedagogical strategies. Second

> activities that extend over time are more likely to allow teachers to try out new practices in their classroom and obtain feedback on their teaching. (pp. 921-922)

This reinforces the notion that time is important; however, such opportunities are also structured and purposeful for teachers.

Collegiality and collaborative exchange with fellow teachers were also identified as characteristics of effective professional development; however, again, such collaboration is structured and purposeful. Guskey (2003) discussed the following:

> educators at all levels value opportunities to work together, reflect on their practices, exchange ideas, and share strategies. But research on teachers shows that individuals can collaborate to block change or inhibit progress just as easily as they can to enhance the process (p. 748).

Collaborative structures and opportunities for teachers are provided, and it is important these opportunities are structured in order to maximize productivity of the participants. This translates into teachers being provided time and the organizational structures to discuss both the implementation of new ideas and reflection on current practices.

Furthermore, teachers are provided with a safe and supportive environment to discuss with colleagues issues of content and pedagogy that focus on mathematics, children's mathematical thinking and the curriculum (Mewborn, 2007). When teachers are provided opportunities for collegial support, this may assist in sustaining changes in their instructional practices over time. As noted by Garet et al. (2001), "professional development may help to contribute to a shared professional culture, in which teachers in a school or teachers who teach the same grade or subject develop a common understanding of instructional goals, methods, problems, and solutions" (Garet et al., 2001, p. 922). Collaborative approaches may also promote school change that may extend throughout the school rather than just occurring in isolated classrooms (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009).

Characteristics also suggested professional development be school based; however, research exists that complicates this notion. A review conducted by the Consortium for Policy Research in Education concluded that when professional development was school based “staff members paid only lip service to research and were interested in programs similar to what they were already doing than in those producing results” (Guskey, 2003, p. 749). Because of this, it is important that collaboration exists between district personnel and professional development educators to establish a broad perspective of the critical contextual characteristics of the district and its teachers (Guskey, 2003). It is also important professional development aligns with reform efforts such as standards-based mathematics instruction and other initiatives in the district (Guskey, 2003).

In general, there is not standard agreement amongst researchers or practitioners as to the criteria defining effective professional development, and there is little measurement of effective professional development practices in conjunction with improving student learning outcomes. Moreover, “although some researchers are beginning to examine the effects of professional development on teaching and learning, few studies have compared the effects of different characteristics of professional development” (Garet et al., 2001, p. 918). Although there is not uniform agreement on the characteristics defining effective professional development, there are common characteristics (such as addressing content and pedagogical knowledge, providing time and opportunities for collaboration) echoed throughout the literature.

The organizational structure of the professional development may also affect how teachers digest and sustain its information. In the literature, the most criticized professional development type is the traditional "workshop." In fact, "more than nine out of 10 U.S. teachers have participated in professional learning consisting of primarily of short-term conferences or workshops" (Darling-Hammond et al., 2009, p. 46). This "workshop is a structured approach to professional development that occurs outside the teacher's own classroom" (Garet at al., 2001, p. 920). It involves leaders with special expertise and is criticized as being ineffective at providing teachers with sufficient time, activities and content to enhance their knowledge and changes in classroom practice (Garet et al., 2001). Stein, Smith & Silver (1999) explained the following:

> these forms of professional development were designed to support a paradigm of teaching and learning in which students' roles consisted of practicing and memorizing straightforward facts and skills, and teachers' roles consisted of demonstrating procedures, assigning tasks, and grading students. (p. 238)

Specifically, in mathematics education, traditional workshop professional development further contradicts the tenets underlying standards-based mathematics instruction.

Although workshops exist that are based upon research-proven practices, many of the workshops of which the majority of U.S. teachers receive demonstrate the characteristics of not providing teachers with sufficient time, activities and relevant content. Darling-Hammond et al. (2009) discussed:

> U.S. teachers participate in workshops and short-term professional development events at similar levels as teachers in other nations. But the United States is far behind providing public school teachers with opportunities to participate in extended learning opportunities and productive collaborative communities (p. 48).

Even though teachers are receiving professional development, the educational structures in the U.S. do not easily lend themselves to continued growth and development. Consequently, "the intensity and duration of professional development offered to U.S. teachers is not at the level that research suggests is necessary to have noticeable impacts on instruction and student learning" (Darling-Hammond, 2009, p. 46). As a result, there is growing interest in providing reform types of professional development such as study groups, mentoring and coaching which occur within the context of a teacher's school day. Such reform types of professional development provide opportunities for teachers to have a long-term focus on their current work.

In professional development experiences such as study groups, mentoring and coaching, the emphasis of the professional development occurs during the school day. As Garet et al. (2001) indicated "by locating opportunities within a teacher's regular work day, reform types of professional development may be more likely than traditional forms to make connections with classroom teaching, and they may be easier to sustain over time" (p. 921). This allows for teachers to collaborate on instructional planning, it provides opportunities for mentoring or peer coaching, and it allows teachers to conduct research on their practices within the context of their classroom (Darling-Hammond et al., 2009). In addition, the experiences may be more responsive to the needs and goals of teachers and how they learn, which means they may have a greater influence of changing classroom practices (Garet et al., 2001).

An additional core feature of effective professional development is the extent it provides for active learning for teachers to become engaged in the analysis of teaching and learning (Garet et al., 2001, p. 920). Specifically, Garet et al. (2001) defined active learning as observing expert teachers, being observed, planning how to utilize new methods and materials, reviewing student work and engaging in written work. Hill (2004) echoed the importance of active learning because in active/inquiry learning teachers are able to construct meaning through inquiry and/or analysis. Further, Darling-Hammond (1998) also argued that professional development be grounded in questions, inquiry and experimentation of teachers in conjunction with the research surrounding teaching and learning. Active learning means teachers are personally involved in constructing meaning of the nature of teaching and learning. Teachers are able to contribute to their own professional growth through their daily classroom work.

The final structural core feature Garet et al. (2001) indicated as essential to effective professional development is coherence within teachers' professional development. This notion of coherence is measured in different ways such as the connections of the professional development experiences to other goals, alignment with state and district standards and assessments and communication with other colleagues (Garet et al., 2001). Darling-Hammond (1998) identified this notion of coherence as significant for the professional development design to actually improve teaching; furthermore, she indicated professional development is connected to other aspects of school change. Professional development experiences relate, and teachers understand how the professional development connects to their current work.

2.2.3 PROFESSIONAL DEVELOPMENT IN MATHEMATICS

In addition to the characteristics of effective professional development in general are effective professional development related specifically to mathematics instruction. In a study conducted by Brown, Smith & Stein (1996) on the professional development of middle school teachers, teachers were identified to have positive reactions to professional development, as related to mathematics, under certain conditions (Hill, 2004). The conditions are professional development is focused on content, grounded in artifacts of practice, supported over time, provided time for analysis and reflection and embedded in a system of both assessments and curriculum that support student learning (Hill, 2004; Loucks-Horsley & Matsumoto, 1999).

The importance of grounding a teacher's professional development in practice and focusing on content continues to be emphasized throughout the literature. According to Walker (2007), it is important to use videotaped lessons, student work and teacher reflections as these situate the work within the context of teaching; furthermore, Walker (2007) states "that it is important to analyze and compare teacher talk and practice, because teacher's perceptions may not align with the reality of their classroom" (p. 131). Providing professional development experiences that are contextual for teachers allow teachers to test their knowledge in their own classrooms. This is important if professional development knowledge is to affect and change instructional practices.

Furthermore, teachers are to view their classrooms as "natural extensions of the professional development work" (Mewborne, 2007, p. 49). Professional development experiences focusing on content and how students learn may have a greater effect on student achievement and a student's conceptual understanding (Garet et al., 2001). As Garet et al. (2001) indicated, teachers who increase their content knowledge and skills are more likely to report a change in their classroom practices. Garet et al. (2001) explained:

> our results indicate that professional development that focuses on academic subject matter (content), gives teachers opportunities for 'hands-on' work (active learning), and is integrated into the daily life of school (coherence), is more likely to produce enhanced knowledge and skills. (p. 935)

Professional development does not interrupt the work of teachers rather it is an extension of their work.

Throughout the literature, the importance of mathematical content continues to be emphasized. Such experiences provide activities for teachers to deepen mathematical content rather than simply providing opportunities for teachers to participate in activities; moreover, teachers are able to understand subject matters, learners/learning and teaching methods (Loucks-Horsley & Matsumoto, 1999). According to Walker (2007), "often times professional development for elementary teachers is heavily activity focused—but this may limit the deep mathematical problem solving which could occur if teachers were given activities plus problem solving opportunities to correct their own misunderstandings and conceptions" (p. 131). Professional development experiences focusing on content and pedagogical content knowledge are designed to provide teachers "the opportunity to increase knowledge of subject matter, subject matter used in teaching, or pedagogical content knowledge" (Hill, 2004, p. 219). To affect classroom practice, professional development heavily addresses both content knowledge and pedagogical knowledge.

Sustaining this type of professional development requires support over time. This means providing teachers with time to meet with colleagues to discuss implementation of new practices and the reflection on how new practices unfold in the classroom setting (Mewborne, 2007). Garet et al. (2001) suggested the duration of a teacher's professional development experience is related to the depth of teacher change in their current instructional practice. In fact, "according to the research, intensive professional development that offered an average of 49 hours in a year boosted student achievement" (Darling-Hammond et al., 2009, p. 43). Garet et al. (2001) explained:

> first, longer activities are more likely to provide an opportunity for in-depth discussion of content, student conceptions and misconceptions, and pedagogical strategies. Second

> activities that extend over time are more likely to allow teachers to try out new practices in their classroom and obtain feedback on their teaching. (pp. 921-922)

Professional development experiences of a longer duration and focus are more likely to affect instructional practices. Darling-Hammond (2009) discussed:

> an analysis of well-designed experiential studies found that a set of programs that offered substantial contact hours of professional development (ranging from 30 to 100 hours in total) spread over six to 12 months showed a positive and significant effect on student achievement gains. (p. 43)

Moreover, there is evidence that lengthier professional development experiences may also positively impact student achievement. These types of professional development experiences allow for greater change in instructional practices; however, they also have to be sustained. Darling-Hammond (1998) suggested professional development strategies that succeed in improving instruction be sustained, intensive and supported by modeling, coaching and problem solving centered on specific problems of practice of teachers.

To further support teacher learning, embedding professional development in a teacher's curriculum and assessment systems is important (Hill, 2004). This suggests professional development demonstrate some type of coherence between its activities and the standards of practices occurring in the school. It provides opportunities for teachers to learn, implement, use, or adapt curriculum materials while also addressing content knowledge and teaching skills (Loucks-Horsley & Matsumoto, 1999). The professional development also connects to the goals and other activities that align with state and district standards and assessments (Garet et al., 2001). As stated by Darling-Hammond (2007), "teachers need to know about curriculum resources and technologies to connect their students with sources of information and knowledge that allow them to explore ideas, acquire and synthesize information, and frame and solve problems" (p. 6). Such professional development provides opportunities for collaboration and involves teachers in both curriculum and assessment planning with their fellow colleagues (Darling-Hammond, 1998).

Hill (2004) described additional characteristics that are specific to providing effective and sustained professional development learning opportunities for mathematics instruction. Teachers benefit from being exposed to examples from classroom practice such as student work, materials, and classroom videos (Hill, 2004). This is related to the notion that professional development experiences are grounded in a teacher's professional practice and embedded in the teacher's system of assessments and curriculum.

Professional development experiences model effective and relevant pedagogy within the professional development experiences; moreover, "professional developers themselves model constructivist teaching" (Hill, 2004, p. 219). This reflects teachers being active participants in their own learning and suggests reform-based professional development activities, such as lesson study, may help to promote inquiry based learning. According to Taylor, Anderson, Meyer, Wagner & West (2005), the lesson study model uses "inquiry groups" as a vehicle for improving mathematics instruction. Garet et al. (2001) also emphasized the importance of both active and constructivist learning for teachers. They suggest providing teachers with active learning activities such as observing expert teachers, being observed, planning new methods and materials to incorporate into classrooms, reviewing student work, leading discussions and engaging in written work.

Hill (2004) also indicated teachers participate in opportunities for reflection, practice and feedback in the professional development process. These opportunities allow teachers to "return to their classrooms, try new ideas, then receive support or supervision via observation or follow-up professional development" (Hill, 2004, p. 219). This is an important consideration if professional development is to affect and transform classroom practices.

According to Mewborne (2007), "teachers need to revise the mathematics they are teaching to gain insights into the conceptual underpinnings of topics and the interconnections among topics" (p. 49). Darling-Hammond (1989) explained the following:

> teachers need to be able to analyze and reflect on their practice, to assess the effects of their teaching, and to refine and improve their instruction. They must continuously evaluate what students are thinking and understanding and reshape their plans to take account of what they've discovered. (p. 5)

Teachers are provided with opportunities to try out these practices, reflect on the practices and collaborate with colleagues regarding their effectiveness. Professional development also focuses on student learning; moreover, teachers are provided with the "opportunity to engage in activities that strengthen teachers' knowledge of how children learn" (Hill, 2004, p. 219). Providing professional development experiences that allow teachers to build upon their understanding of how students view and understand mathematics is important if such professional development is to affect instructional practices and promote standards-based mathematical practices.

Finally, teachers are also involved in the planning of their own professional development. Using their own self-identified needs, teachers can choose the professional development they wish to participate (Hill, 2004). This translates into both teachers and administrators identifying appropriate professional development experiences relating to teachers' needs. In addition, Garet et al. (2001) suggested the selection of the professional development for teachers matters as to the likelihood of obtaining teacher buy as the "extend to which professional development activities are perceived by teachers to be part of a coherent program of teacher learning" (p. 927). Teachers are provided opportunities to have a voice in their own professional growth and professional learning experiences.

2.2.4 PROMOTING TEACHER LEARNING

During the past two decades, there has been a transformation as to the types of professional development offered to teachers. With the release of the TIMSS results sparked a desire to study professional development opportunities teachers in higher performing countries were experiencing. Specifically, Hill (2009) explained:

> advocates of continuing teacher education have promoted school-based learning opportunities, such as coaching and lesson study; new topics, in the form of increased focus on subject matter content and, more recently, the analysis of assessment and related data; and new delivery mechanisms, including content transmitted online. (p. 470)

Prior to this paradigm shift in thinking about professional development, the majority of professional development experiences of which teachers participated were categorized as a workshop or some type of offsite course. According to Hill (2004), "and despite the popularity of newer models of staff development (e.g., peer coaching, lesson study) among researchers, traditional in-service workshops remain the most common form" (p. 218). Workshops involve instruction provided by some type of leader who has special expertise. In addition, typical institutes, courses and conferences of which teachers participate are also categorized as traditional workshops. As Garet et al. (2001) stated:

institutes, courses and conferences are other traditional forms of professional development that share many of the features of the workshops, in that they tend to take place outside of the teacher's school or classroom; and they involve a leader or leaders with special expertise and participants who attend at scheduled times (p. 920).

Workshops continue as a prevalent professional development mechanism for teachers in the U.S.

This type of professional development experience is considered traditional in thinking about the frameworks for professional development and is criticized as being ineffective at providing teachers with a sufficient amount of time, activities and content to promote a teacher's knowledge and changes of instructional practice (Garet et al., 2001). Professional development structures like this further contribute to the lack of collaboration occurring between teachers. According to Darling-Hammond et al. (2009), "U.S. teachers report little professional collaboration in designing curriculum and sharing practices, and the collaboration that occurs tends to be weak and not focused on strengthening teaching and learning" (p. 46). These workshops structures typically do little to contribute and promote teacher collaboration.

As a result, there has been a growing interest in reform types of professional development. As the professional development offered to teachers in high-performing countries is studied, it becomes clear "nations that outperform the United States on international assessments invest heavily in professional learning and build time for ongoing, sustained teachers development and collaboration into teachers' work hours" (Darling-Hammond, 2009, p. 48). Professional development experiences considered to be more reform-based include lesson study, action research, study groups, instructional coaching, and mentoring. These experiences promote collaborative work that "afford teachers the important opportunities to share 'craft wisdom' and build a professional culture that focuses on collective energy on student learning"

(Loucks-Horsley & Matsumoto, 1999, p. 264). In Southwestern Pennsylvania, the professional development opportunities offered through the Math Science Partnership (MSP), funded by the National Science Foundation and United States Department of Education, incorporated elements of reform-based professional development while also promoting standards-based mathematical instructional practices. The following sections will elaborate briefly on the reform-based professional development experiences previously identified.

2.2.4.1 Lesson Study

Lesson study is a professional development model used in Japan where teachers participate across a district or a school, and the topic of the lesson study is selected by the teachers and linked to a larger national, district or school goal (Taylor et al., 2005). As a result of findings of the TIMSS study, adaptation of lesson study as professional development tool for U.S. teachers has increased substantially. Mathematics teachers are encouraged to collaborate with colleagues regarding instructional practices, and lesson study serves a professional development vehicle to do so. Institutions such as Intermediate Units and the Math Science Partnership (MSP) have offered lesson study protocols to assist teachers with participation in the process.

Furthermore, lesson study serves as a vehicle for instructional improvement where teachers work collaboratively to formulate student learning goals, plan research lessons designed to capture those goals, execute the lesson with other team members focusing on evidence of student learning, reflecting on and discussing the evidence gathered and using these to improve and revise the lesson (Perry & Lewis, 2009). As Taylor et al. (2005) explained:

> teachers, usually of the same grade level, meet weekly to design, teach and evaluate one research lesson. Their next steps are to revise the lesson, reteach it, evaluate, reflect on the lesson again, and share their results. This process may take up to one year. (p. 18)

Lesson study is an opportunity where teachers can collaborate deeply with colleagues in an effort to refine and improve instruction.

The implementation of lesson study with United States teachers has occurred; however, it exists within the operational sense of structure within schools (Hill, 2009). This means lesson study opportunities are being provided to U.S. teachers; however, evidence exists that the intensive amount of time needed is not being provided. According to Hill (2009), "although the model calls for an extensive time commitment by teachers, almost 60% of those who participated reporting spending eight or fewer hours during the year; only 4% reported engaging in over 80 hours" (p. 470-471). In addition, because lesson study derives from another country and also culture, this may create additional challenges for it to be successful in the context of the U.S. educational system (Perry & Lewis, 2009). Hurd, Lewis, O'Connell & Perry (2006) explained the following:

> one implication of this case is that other U.S. sites may have to go through similar steps to build successful lesson study efforts: establishing authentic professional communities able to address conflicting ideas and build teachers' knowledge, breaking down traditional hierarchical relationships within the system and walls that keep classroom practices private; focusing on student thinking; taking initiative to draw on external knowledge sources; and realizing that the shared research lesson (an unfamiliar form) can provide a solid basis for collaborative reflection about students' progress toward instructional goals. (p. 387)

This reflects the notion that cultural barriers within schools in the U.S. are to be addressed before lesson study can be implemented as a means of instructional improvement.

In China teachers meet weekly in teacher research groups to “spend substantial amounts of time studying the government’s framework, the textbooks, and the teacher’s manual to understand how topics are sequenced, why particular examples are used, and how to best make use of the material to accomplish the stated objectives” (Mewborne, 2007, p. 50). In this experience, Chinese teachers are expected to teach only three or four class periods (45 minutes) to provide time to do this (Mewborne, 2007, p. 50). In Asian classrooms, there is a systematic practice that exists for teachers to transfer their knowledge while continuing to perfect their teaching practices by providing continuous opportunities for teachers to learn from one another (Darling-Hammond, 1998). Given the collaborative, organic and reflective nature of lesson study, it is a professional development tool highly promoted by mathematical community; however, many of the current cultural organizational structures in U.S. educational systems do not readily lend themselves to this structure of professional practice.

2.2.4.2 Action Research

Action research is a reform-based professional development experience allowing teachers to be active participants of inquiry within their own learning. It provides teachers opportunities to reflect upon and analyze their teaching practices with the purpose of improving their instruction (Ball, 1996). According to Timmerman (2003), “the action research process of collecting and making sense of data in order to inform change is a meaningful way for faculty members to continue their professional growth and development” (p. 155). Garet et al. (2001) suggested when teachers engage in opportunities to present, lead and write upon their findings then “active participation of this kind may improve outcomes by permitting teachers to delve more deeply into the substantive issues being introduced” (p. 926).

Furthermore, Linda Darling-Hammond (1998) reinforced this notion by stating “good settings for teacher learning-in both colleges of education and schools-provide lots of opportunities for research and inquiry, for trying and testing, for talking about and evaluating the results of teaching and learning” (p. 7). She also suggested professional development strategies are grounded in questions, inquiry and participation as well as research (Darling-Hammond, 1998). This supports the notion of action research as a professional development tool that promotes and sustains teacher learning while also providing teachers with the ability to conduct research and act on their own teaching environment.

2.2.4.3 Study Groups, Coaching and Mentoring

In addition, there has been increased interest in using professional development strategies such as study groups, coaching and mentoring. Schools have asked teachers to participate in peer observations, teacher academies, instructional coaching initiatives, school-university partnerships promoting collaborative research and interschool visitations (Garet et al. 2001). The school-university partnerships may include the creation of professional development schools where “these schools aim to provide sites for state-of-the-art practice that are organized to support the training of new professionals, extend the professional development of veteran teachers, and sponsor collaborative research and inquiry” (Darling-Hammond, 1998, p. 7). Darling-Hammond (1998) explained these partnerships:

> envision the professional teacher as one who learns from teaching rather than as one who has finished learning how to teach, and the job of teacher education as developing the

capacity to inquire systematically and sensitively into the nature of learning and the effects of teaching (p. 7).

Through the creation of Professional Learning Communities (PLCs), instructional coaching and Induction mentoring, collaborative professional development opportunities such as these have begun to occur more deliberatively and purposefully in schools and districts.

2.2.4.4 Math Science Partnership Opportunities

In Southwestern Pennsylvania, the Math Science Partnership provided multiple professional development opportunities to both teachers and administrators in an effort to increase student achievement in mathematics and science. The MSP professional development opportunities are grounded in research-based best practices for adult learning. The experiences also have served to build capacity of teachers in both their content and pedagogical content knowledge.

The professional development experiences include Teacher Leadership Academies, On-Site Academies, *Lenses on Learning*, Content Deepening Seminars and Educator Networks. Each experience was available locally and incorporated the utilization of instructional strategies that promoted deep conceptual understanding of mathematics for students. Each professional development opportunity, including the MSP in general, will be discussed in greater detail in the following section.

2.2.5 LIMITATIONS OF PROFESSIONAL DEVELOPMENT

In order to offer reform-based types of professional development in the U.S., current limitations of our educational structures are considered. For example, the capacity of the providers to provide such professional development remains an issue. In 2005, Hill conducted a study of individuals providing professional development to mathematics teachers that asked about their background. The study also asked these developers to solve a series of math problems. Hill (2009) explained the following:

> most respondents said providing mathematics professional development was not their only responsibility; other responsibilities included teaching, coordinating curriculum for districts, and consulting. Their performance on the math assessment varied; in fact, when compared to a large sample of teachers who took the same assessment, roughly one-sixth of the professional development providers fell below the 50th percentile of the teacher sample. (p. 471)

However, in Southwestern Pennsylvania, districts may choose for their teachers to participate in the professional development opportunities offered through the MSP of which providing content based professional development lies as a focus of their responsibilities.

When considering implementation of reform-based professional development opportunities, such as lesson study, it is essential to consider areas of concern that may emerge in U.S. schools. Specifically, Taylor et al., (2005) cited four areas of concern they experienced when implementing lesson study with a group of teachers. Areas of concern consisted of the emphasis on external mandates controlling and limiting their professional lives. In addition, the shift from traditional practices to the consideration of new ideas and practices which lesson study requires proved to be difficult for the group (Taylor et al., 2005). Further, the understanding of the goals and process of lesson study required a significant amount of time and experiences; moreover, administrative support for this process is also required (Taylor et al., 2005).

There is also a lack of information regarding how to measure effectiveness and quality of professional development, and little is known about professional development efforts needed to support mathematical reform efforts such as standards-based instruction (Hill, 2004). Although standards for professional development have been studied, the standards may not differentiate high quality versus low quality professional development in terms of student learning (Hill, 2004). Improving professional development requires changing the structures and supports for professional development; however, it also requires improving how professional development is evaluated. Quality professional development "involves well-designed evaluations of professional development, based on outcome measures agreed jointly by policy makers, teachers, and professional developers" (Hill, 2004, p. 228). This translates into rewriting the standards to provide assistance and clarification to teachers and school officials to emphasize subject matter content and student learning (Hill, 2004). Furthermore, the evaluative measures used for professional development may include "growth in teachers' content knowledge for teaching mathematics, knowledge of students' mathematical learning, or their use of certain instructional or assessment practices" (Hill, 2004, p. 228).

Reshaping professional development to support standards-based mathematics instruction requires systematic changes in addition to professional development changes. Although changes can be made at the school and district level to support reforming professional development efforts, changes with policy makers are considered as well. Isolating changing professional development practices to the participants of professional development experiences is not likely to sustain and support these efforts. In addition, changing policies is not likely to sustain and support these efforts. Such efforts require reshaping both policies and practices as "policies that seek to change instructional practice depend upon—and are changed by—the practice and the practitioners they seek to change" (Cohen & Ball, 1990, p. 238). It requires restructuring the types of professional development practices, standards, and evaluative practices used to measure the quality of professional development experiences offered to teachers. It requires administrators and teachers to promote research-based professional development experiences grounded in the work of teaching and learning. Mathematics teachers in Southwestern PA have had access to this type of reform-based professional development experiences through opportunities provided by the MSP.

2.3 MATH SCIENCE PARTNERSHIP (MSP)

Although much attention has recently been devoted to the increasing the shortage of STEM candidates, concerns for the crucial nature of mathematics and science education existed well before the acronym STEM occurred. In fact, the Math Science Partnership (MSP) was established to address the critical needs of mathematics and science in education in the U.S. before the term STEM was common verbiage. Even recently, there continues to be numerous, growing concerns regarding the quality of U.S. students and their preparedness to undertake STEM careers. Wong, Yin, Moyer-Packenham & Scherer (2008) explained the following:

> the United States faces significant challenges in the fields of science, technology, engineering and mathematics (often collectively referred to as STEM). Numerous reports

> from governmental, scientific, and civic communities have raised concerns over the quality of STEM educational at all levels of the educational system, the shortage in the STEM labor force, and the decreasing competitiveness of student performance in STEM fields at the international level. (p. 479)

The shortage of qualified candidates pursuing STEM careers still continues to be a concern in the U.S.

As a response to the growing concern of mathematics and science education, an expert group the Committee on Prospering in the Global Economy of the 21st Century was convened by the National Academy of Sciences; furthermore, this group recommended federal policy be established to increase the pool of qualified science and engineering students (Yin, 2008). There were also growing concerns of the United States' ability to maintain its' position of global competiveness since U.S. students were performing poorly in mathematics and science (in relation to testing) as compared to their global counterparts (Pane et al., 2009). The Congressional Hearing's Committee on Science (2004) explained the following:

> for decades, educators and policy-makers have seen statistics that demonstrate a lackluster performance of U.S. students in math and science. Results from the National Assessment of Educational Progress show that a majority of U.S. students score below 'proficient' in math and science, and the Third International Math and Science Study highlight our problems relative to other countries. (United States, 2004, p. 4)

The MSP project and its funding were established as part of *No Child Left Behind*. In 2002, Congress established the MSP Program under the National Science Foundation Authorization Act (Pane et al., 2009). An overarching goal of the formation of the MSP was the integration of partnerships with higher education institutions and K-12 public education systems to strengthen and reform mathematics and science education (Tyler & Vitanova, 2008). In addition, the United States Department of Education also authorized funding to be filtered through each state's Department of Education to also support the work of the MSP. As a result, there are currently two funding streams supporting the work of the MSP. The funding streams include the funding provided by NSF and funding provided by individual state Departments of Education.

From a national perspective, the focus of the MSP's work is too many teachers teaching outside their content areas, too few students taking advanced coursework and too few schools offering challenging curricula and textbooks in the fields of mathematics and science (Pane et al., 2009; Tananis, 2010). In 2002, the NSF Authorization Act created a competitive, merit-based grant program that awarded grants to partnerships between institutions of higher education and school districts to improve mathematics and science education by funding innovative programs to develop new models of educational reform and remedying the lack of knowledge of science and mathematics research (United States, 2004). The competitive, merit-based grant programs served as the backbone to the MSP. The MSP Program was designed to reflect the larger mission of the NSF, which is to help the U.S. maintain a position of prominence within the global market of emerging research, sustaining a "world class" workforce of scientists and engineers, and promoting and developing scientific literacy amongst the U.S. population (Yin, 2008).

Moreover, the "NSF's Math and Science Partnership (MSP) competitively awards grants to institutions of higher education, or other eligible nonprofits, and their partners—one or more school districts—to improve K-12 math and science education (United States, 2004, p. 5). The NSF supports the MSP through two types of grant partnerships Comprehensive and Targeted. Comprehensive partnerships are designed to reflect change in the K-16 educational continuum and improve student achievement across the K-12 continuum; these grants may be funded up to $7 million annually over a five-year period (Williams, Pane, Tananis, Olmsted & Ciminillo, 2006). Targeted projects focus on improving K-12 achievement within a discipline focus (mathematics or science) or focus on a specific grade band, and these partnerships may be funded up to $2.5 million annually up to 5 years (Williams et al., 2006).

2.3.1 MSP OF SOUTHWESTERN PENNSYLVANIA

The Math Science Partnership of Southwestern Pennsylvania, which is located at the Allegheny Intermediate Unit, was initially established as a Comprehensive partnership connecting both K-12 educational organizations with higher educational institutions in order to increase the capacity of the K-16 educational continuum. Through this partnership, it was expected the MSP organization would implement substantial changes in both mathematics and science across the K-12 educational continuum (National Science Foundation, 2006, p. 3). Beginning in 2003, the MSP of Southwestern PA was one of seven Comprehensive projects awarded grant funding of approximately $18 million by NSF; furthermore, through this partnership the MSP focused on implementing changes across the K-12 continuum in mathematics and science while also establishing partnerships between the K-12 schools and the region's higher educational institutions (Pelkowski & Wang, 2010; Tananis, 2010).

The MSP of Southwestern PA serves urban, suburban and rural districts. In addition to the school districts served, the Southwestern PA MSP also included four Institutions of Higher Education (IHEs) and four partner Intermediate Units (IUs) (Tananis, 2010). The four partner IHE's were Carlow University, Chatham University, Robert Morris University and St. Vincent

College. The NSF grant awarded funding supported 45 of the local districts in Southwest Pennsylvania who participated in this project; however, additional funding ($3 million) was also awarded by the Pennsylvania Department of Education (PDE) for eight additional resource districts to participate (Pane, Williams, Olmstead, Yaun, Spindler & Slaughter, 2009).

According to Pane et al. (2009), the total enrollment of students in the Southwestern PA MSP is approximately 114,000 students with an average of 2,150 students per district; each typical MSP district services four to five schools within it. On average, 39% of students in MSP schools were considered economically disadvantaged as compared to the state average of 36% (Pane et al., 2009). Minority representation of students was 19% in the MSP as compared to the state average of 22% (Pane et al., 2009). The number of economically disadvantaged students was higher (59%) for PDE funded MSP districts as compared to the NSF funded MSP districts, and the underrepresented minority representation was also higher (25%) in the PDE MSP districts (Tananis, 2010). Because PDE's funding stream was used for low resource districts, this explains why the number of disadvantaged and minority students was higher when compared to the NSF funded districts.

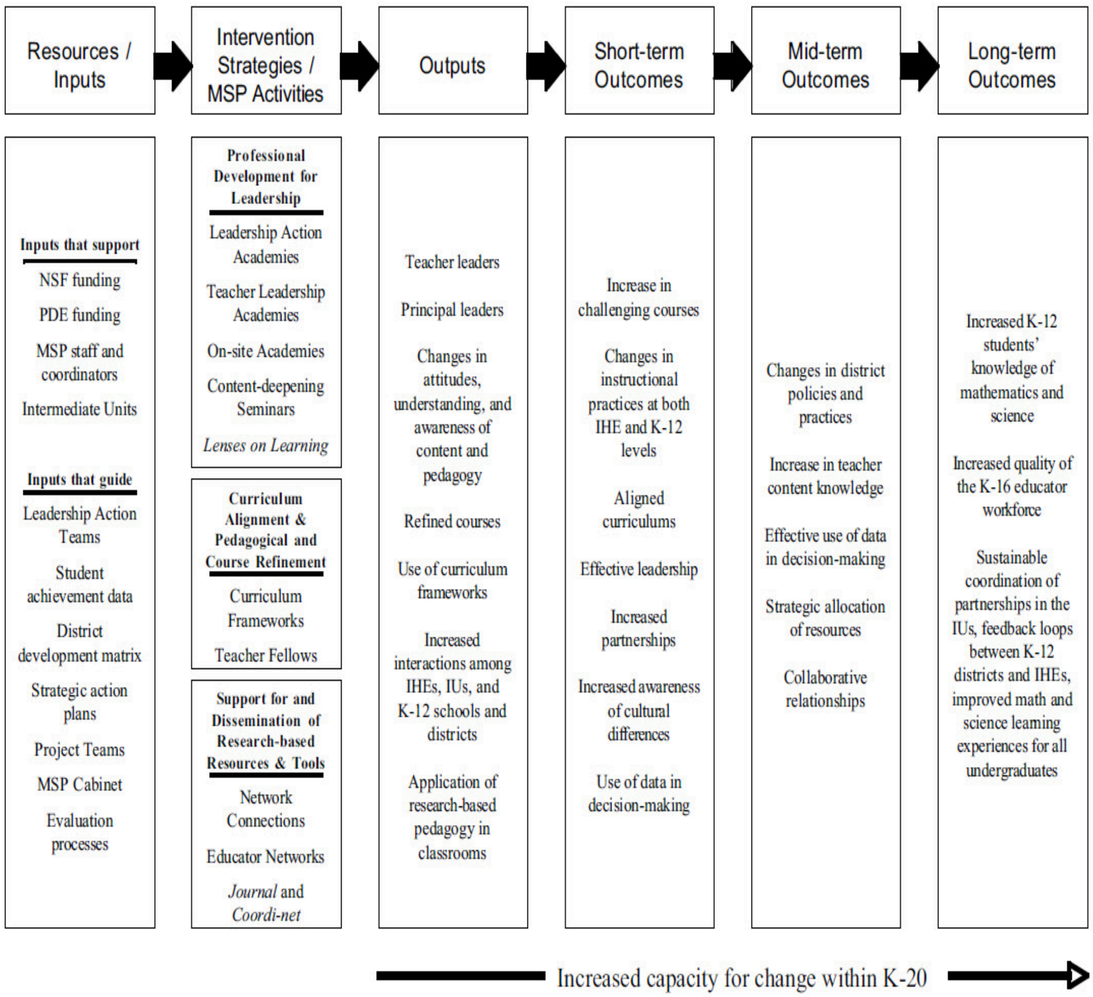
The goals of the Southwestern PA MSP project reflected the same principles as the goals of the previously discussed NSF MSP. For the Southwestern PA MSP, the goals were to (1) increase K-12 students' knowledge of mathematics and science, (2) increase the quality of the K-16 educator workforce, and (3) create a sustainable coordination of partnerships in the IUs, building intentional feedback loops between the K-12 districts and IHEs, tapping the discipline-based expertise of the IHEs, and improving the mathematics and science learning experiences for all undergraduates (Pane et al., 2009; Tananis, 2012). The theory of action grounding the work of the MSP was the idea that student achievement will increase when teachers are able to increase their conceptual understanding of big ideas in both mathematics and science (Williams et al., 2006). The theory of action described the action of the Southwestern PA MSP and was similar to the theory of action for the NSF-supported local systemic change. Williams et al. (2006) explained the following:

> providing teachers with opportunities to deepen their content and pedagogical knowledge in the context of high-quality instructional materials will result in better prepared teachers. With ongoing support, teachers will be more inclined to change their instruction in ways advocated by national standards, and will have more capacity to do so. (p. 18)

This theory of action argued that providing opportunities for teachers to strengthen their content and pedagogical content knowledge is more likely to result in change in teacher practice.

In an effort to address the Southwestern PA's MSP's theory of action and its long-term goals, the MSP Assessment and Evaluation Team developed a logic model highlighting the intervention strategies the MSP utilized to meet its long-term goals (See Figure 1). This model served as the basis for evaluation and was included as a visual representation of the MSP's thinking. It also described the MSP's theory of action; furthermore, the logic model reflects findings from both Japanese and U.S. educators who identified Key Pathways to Instructional Improvement (Williams et al., 2006). These pathways lead to ongoing instructional improvement, and they include increased knowledge of subject matter, increased knowledge of instruction, increased ability to observe students, stronger collegial networks, stronger connection of daily-practice to long-term goals, strong motivation and sense of efficacy, and improved quality of lesson plans (Lewis, Perry & Hurd, 2004). Many of these are directly observed in the logic model.

Figure 1: MSP Logic Model (Williams, Pane, Tananis & Olmsted, 2005)



This logic model delineates the resources needed for the intervention strategies the MSP utilized to obtain its long-term goals; moreover, it also features the outputs that one expected to occur as a result of the intervention strategies. In addition, the logic model highlights the outcomes of the MSP project and its work. The outcomes are classified into short-term outcomes (identifying increases in knowledge, skills and awareness), mid-term outcomes (changes in behavior, policy or implementation of practices, and the long-term outcomes (the project goals which have previously been identified) (Williams, Pane, Olmstead & Tananis, 2005). The focus of this research study centers upon one of the identified mid-term outcomes in the logic model: changes in classroom instructional practice at the K-12 level.

2.3.2 MSP INTERVENTION STRATEGIES

2.3.2.1 MSP Goals and Intervention Strategies

To achieve its long-term goals, the MSP of Southwestern PA used three intervention strategies. The intervention strategies are as follows:

1. Professional Development for both Content and Leadership
2. Curriculum Alignment and Pedagogical Course Refinement
3. Support for the Dissemination of Research-Based Curricula

Each of the intervention strategies are described in more detail in the following sections. Because this research study revolves around the MSP's intervention strategy of professional development, this intervention will be discussed last and in greater detail.

2.3.2.2 Curriculum Framework

The second intervention strategy identified in the MSP logic model is curriculum alignment and pedagogical course refinement. This included using curriculum frameworks at the K-12 level and also working with faculty to refine IHE courses (Pane et al., 2009). The curriculum frameworks identified the big mathematical ideas that addressed the PA Standards and the PA Eligible Content; moreover, the primary goal of the curriculum frameworks was to allow teachers to teach to greater depth with less repetition eliminating the notion of curriculum being a mile wide and an inch deep (Pane et al., 2009). The curriculum framework also aligned to the big ideas of NCTM and the TIMSS assessment. This framework, along with the PSSA data, TIMSS studies and the TIMSS study conducted of the Western PA region, provided districts with a basis to assess and analyze their curriculum for potential gaps and challenges (Williams et al., 2006). It also provided teachers with an opportunity to teach content in greater depth and to a higher level of student conceptual understanding by focusing the number of content areas to be taught at each grade level.

For refinement of the IHE courses, teacher fellows were selected to work with IHE faculty and refine two courses for which pre-service teachers enroll (Pane et al., 2009). According to Pane et al. (2009), "through course revision, it is intended that IHE faculty will become more familiar with state and national content standards and that the teacher fellows will become more familiar with the depth and scope of specific content" (p. 9). As a result, the K-16 partnership strengthens and teacher fellows were able to increase their content knowledge.

2.3.2.3 Dissemination of Research Based Materials

A second MSP intervention strategy identified consisted of the MSP providing support for the dissemination of research-based resources and tools. To do this, the MSP utilized both conferences and networks. For example, The *Network Connections* conference has been offered in fall and late winter since 1995 (Williams et al., 2006). This conference provides districts with **INTERACT** time (Invitation to Effectively Reflect **a**nd Collaborate Time) offering districts time to collaborate and debrief (Williams et al., 2006). During this time, Leadership Action Teams (LATs) comprised of district administrators, six faculty members (mathematics and science teachers from each level) and a guidance counselor used this as planning time to develop action plans for implementation of the MSP efforts in their districts. Because of the frequency of administrative turnover occurring in the Southwestern PA area, the MSP determined the importance of establishing these Leadership Action Planning Teams to consist of a "vertical slice" of leaders at each level (Bunt, 2010). Moreover, "over the seven years of the MSP project, three-fourths of the K-12 superintendents and IHE presidents have changed, as well as 70% of building principals" (Bunt, 2010, p. 1). Given the high rate of turnover of administrative leadership, the establishment of LATs with both teachers and administrators was extremely important to the sustainability of the MSP efforts. The LATs were essential to analyzing student and organizational data in an effort to develop and implement annual action plans in an effort to increase student achievement in mathematics (Bunt, 2010).

Educator Networks were another avenue for the MSP to disseminate research-based materials and tools. Within the networks, inter-district groups of teachers formed communities of practice centered upon the use of research-based materials such as *Everyday Math*, *Connected Math*, and *Investigations* (Williams et al., 2006). The meetings typically occurred 3-4 times per year and were open to all interested districts; the meetings served to increase teachers' content and pedagogical knowledge through building the capacity for the use of research-based materials.

In addition, MSP produced publications, the *Math & Science Journal* and *Coordi-net*, which also assisted with the interventions. The *Math & Science Journal* continues to be produced and is distributed annually to all mathematics and science teachers within an 11 county area. Within the *Journal*, research-based instructional practices are recognized and promoted; the *Math & Science Journal* is also distributed to districts through IU Curriculum Council meetings. *Coordi-net* provided a mid-year update on MSP professional development opportunities offered. These publications are examples of the MSP's efforts in Southwestern PA to promote the dissemination of research-based information.

2.3.2.4 Professional Development

Professional development addressing both teachers' content knowledge and leadership was and continues to be a significant intervention strategy being used by the MSP, and the "overriding purpose of these activities is to equip teachers with content, pedagogy, and leadership skills necessary to become effective leaders in their institutions" (Pane et al., 2009, p. 5). Furthermore, the professional development was not exclusive to teachers. Using *Lenses on Learning*, the MSP of Southwestern PA had also provided professional development for administrators. Through the MSP, there was a concerted effort to address professional development needs for both teachers and administrators as they related to increasing mathematics achievement.

The MSP's intensive professional development opportunities were designed to create cadres of teacher leaders equipped with the capacity to lead professional development efforts within their own districts. Through the Teacher Leadership Academies (TLAs), the primary focus of the Southwestern PA MSP was the Teacher Leader since "teachers supply the change in pedagogy necessary to directly influence opportunities for student learning" (Tananis, 2010, p. 14). Examples included the Teacher Leadership Academies (TLAs) and the On-site Academies (OSAs). Through the professional development opportunities, "the TLAs and OSAs are expected to build the capacity for change among MSP partners by providing training in math and science content as well as pedagogy" (Pane et al., 2009, p. 7).

Within the TLAs, selected teachers participated in ongoing professional development focused upon strengthening a teacher's content and pedagogical knowledge. It was the expectation of the MSP that the Teacher Leaders conducted this same professional development with their fellow staff members. This on-site professional development led by Teacher Leaders was referred to as the On-Site Academies.

Both the TLAs and OSAs required an extensive amount of time from the participants. As discussed in the literature review, one of the characteristics of effective professional development is that it be on-going and continuous. Furthermore, there is evidence suggesting teachers who receive a substantial amount of professional development experiences can boost their student's achievement levels by approximately 21 percentile points (Yoon, Duncan, Silvia, Scaroloss & Shapley, 2007). These MSP professional development opportunities were continuous, ongoing and within the context of the teacher's work; they also demonstrated the other characteristics that emerged as essential for professional development to affect teachers and create change.

The important role of administrators was recognized in the efforts of the MSP. The MSP recognized that "without structural and process-oriented changes to support reform-based pedagogy, instructional practices become stagnant and isolated in individual classrooms" (Tananis, 2010, p. 14). Through *Lenses on Learning*, the MSP offered professional development that assisted administrators in recognizing research-based effective instructional practices to be encouraged and promoted throughout their schools. Through *Lenses on Learning*, there was a concerted effort to address the professional development needs of administrators as they pertain to mathematics; however, the vast majority of the MSP's professional development efforts were concerned with the teacher leader.

In an analysis of teacher participants in the TLAs in Southwestern PA, On-Site academies had the greatest number of teacher participants while the Teacher Leader Academies had the highest mean (76.3) participation hours by participants (Goodlin, Johnson, Olenik, Kirby McConnell & Yugar, 2009). All of the professional development opportunities included content knowledge in mathematics with the belief that when teachers are "more familiar and comfortable with content, teachers are better able to engage in deeper reconstruction of their teaching and to link content knowledge with pedagogical content knowledge" (Tananis, 2010, p. 13).

In a study from 2004 to 2010, teacher participants of the MSP professional development opportunities were administered the Content Knowledge for Teaching Mathematics (CKTM) developed by the Learning Mathematics for Teaching Project from the University of Michigan (Goodlin et al., 2009). According to Goodlin et al. (2009), this CKTM tool is an instrument used to assess a teachers' mathematical content knowledge within the following subscales: Numbers and Operations (Grades K-8), Patterns, Functions and Algebra (Grades K-8), and Geometry (Grades 3-8). The elementary teachers were administered the CKTM measure on Numbers and

Operations since this most aligned to the work of the MSP's professional development academies; whereas, the secondary teachers were administered the CKTM measure on Patterns, Functions and Operations since this most aligned to the work of the MSP's professional development academies for secondary teachers (Goodlin et al., 2009).

In this study, over half of the 968 participating elementary teachers made gains on their post-test CKTM scores with the largest gains of improvement occurring with teachers who had participated in the TLAs (Goodlin et al., 2009). When analyzing the scores for the 202 participating secondary teachers, the results were consistent with the elementary teachers. The post-scores CKTM scores were significantly higher than the pre-test scores with the largest gain occurring with secondary teachers participating in the TLAs (Goodlin et al., 2009). According to Goodlin et al. (2009), "regression analyses found significant relationships between participation and changes in teachers' scores on the content knowledge measure for both elementary and secondary teachers" (p. 1).

2.3.3 MSP TEACHER PROFESSIONAL DEVELOPMENT

Although much of the aim of the MSP professional development was directed towards the Teacher Leader through the TLAs, other MSP professional development activities have also been offered (See Table 1). As referenced in the logic model, the MSP activities that addressed the intervention strategy of professional development for content and leadership consisted of the following: Leadership Action Teams, Teacher Leadership Academies, On-Site Academies, Content Deepening Seminars and *Lenses on Learning*. This research study is rooted in the experiences gleaned from the Teacher Leadership Academy; however, each of the professional development options is described to provide a complete overview of the holistic view of professional development that the MSP provided to its districts in relation to its goals.

Table 1: Professional Development Activities of the MSP (Tananis, 2005)

MSP Activity	Description
Leadership Action Teams and Leadership Action Academies	Leadership Action Teams represented each school district and IHE. Each team assessed strengths and weaknesses in its institution and developed an action plan for improvement. The teams selected teachers and administrators to participate in the other MSP activities. District LATs met collectively four times per year in the Leadership Action Academies, and IHE LATs met as necessary on their campuses.
Teacher Leadership Academies	Leadership development for selected teachers, grounded by discipline/level (elementary math, secondary math, and 9^{th}-12^{th} grade science). In the NSF funding supported years, trainings (Level 1 & 2) occurred over a two-year period, and totaled 20 days: five days each summer and five days during each school year. The teacher leaders were expected to go back to their school districts and develop "communities of learning," sharing what they learned in the academies with fellow teachers during on-site professional development in their own districts (On-Site Academies). Level 3 was only 3 days during the summer with school year follow up.
Principals' Seminars	Training seminars, entitled *Lenses on Learning*, for district principals to build a deeper understanding of effective mathematics instruction, and develop effective observing and conferencing techniques. These sessions totaled 38 hours over a one-year period. An additional module was added to support science education supervision as well.
Teacher Fellows	Support for two teachers from each district over the five-year grant period to spend one or two terms at a partner IHE. During each term, the Teacher Fellow worked with IHE faculty to help refine two IHE courses, take a college course, and assist in MSP activities.
Network Connections	Daylong conference held twice a year, for Leadership Action Teams and other math and science teachers and faculty to explore resources and tools.
Educator Networks	Activities to assist districts in implementing challenging courses and curricula. Groups of teachers from across the region (MSP and non-MSP districts) who were using the same curricula (e.g., Everyday Math, Connected Math, Investigations, etc.) met to share best practices. State-funded Math Coaches have also formed an Educator Network to support shared learning.
Content Deepening Seminars	Vouchers and stipends supported teachers to attend professional development in math or science content areas sponsored by IHE partners and others, in order to help them become content area resources for peers in their districts.

2.3.3.1 Leadership Action Teams

As previously discussed, the LATs were comprised of a “vertical slice” of district leadership. The LAT provided an opportunity for district teams to engage in the process of analyzing data to develop and implement their district-created, data-driven action plans. A district administrator appointed by the superintendent led the teams; they were also comprised of a mathematics and science teacher from each level (elementary, middle and high school). The LATs convened four times a year with two of these meetings occurring at the *Network Connections* conference scheduled in both the spring and the fall; moreover, this provided time for the LATs to establish goals, explore and discuss resources, create cadres of teacher leaders to deliver professional development and build action plans (Tananis, 2005). In addition, it was through the work of the LATs that the majority of the MSP professional development experiences were executed at the district’s local level. The LATs helped to determine professional development needs and establish the resources needed to implement the On-site Academies.

2.3.3.2 Teacher Leadership Academy (TLA)

Because much emphasis of the MSP’s efforts focused upon the Teacher Leader, the TLAs were an integral component of advancing the work of the MSP. In the NSF supported years, the Math & Science Collaborative (MSC) offered academies. The Teacher Leadership Academies were a teacher leader model that began with a five day immersion of participants exploring mathematical content and pedagogical instructional strategies promoting the conceptual understanding of mathematics for students. Each TLA began in the summer and focused upon content and pedagogy relative to specific grade levels; moreover, the academies also explored potential issues that occurred relative to the role of teacher leader (Williams et al., 2006). In addition to the week-long opportunity in the summer, follow up sessions were offered during the school year. Teacher Leaders who participated in the academies were expected to provide the same professional development experiences for their colleagues in their schools through the On-Site Academies. It was the expectation that through On-Site Academies the Teacher Leaders provided 24 hours of professional development to their fellow staff members (Williams et al., 2006). As of 2006, the number of teachers participating in the TLAs was 201 with 38 of the 40 NSF funded MSP districts participating in the academies.

TLAs for mathematics were offered at both the elementary and secondary levels. The Elementary TLAs serviced teachers for grades K-6; whereas, the Secondary Mathematics TLAs serviced teachers grades 7-12. For the purposes of this study, the term TLAs will refer to the Secondary Mathematics TLA. Beginning in the summer of 2004, 83 teachers from 45 districts started this work (Malik, 2004). The TLAs commenced as a two-year program with teachers participating each year in a five day summer session with additional professional development opportunities occurring throughout the school year. There was a third year focused on lesson study that consisted of three days of training in the summer with school year follow up. The purpose of the TLAs was "for teacher leaders to support the building of learning communities within the local school districts using a variety of research-based tools" (Malik, 2004, p. 39). The research-based tools included the Mathematical Tasks Framework, Videocases for Mathematics Professional Development (VCMPD) and the regional K-12 curriculum framework.

The Mathematical Tasks Framework is "a representation of how the types of mathematical problems selected will affect classroom instruction" (Malik, 2004, p. 39). This framework provided teachers with an understanding of how the selection of a task affects how students become engaged with mathematics. The framework also offered teachers insight as to how to be strategic in the selection of mathematical tasks for their students. As Malik (2004) indicates, teachers recognized “how the Mathematical Task Framework can be used as a lens for reflection on and discussion of the factors that contribute to the maintenance or decline of cognitive demands on the students as the task is unleashed in the classroom” (p. 38). Further, the use of the VCMPD tools provided opportunities for teachers to revisit and re-examine both their content and pedagogical knowledge. Malik (2004) explained the following:

> case-based methodology to investigate the complexities of mathematics teaching and learning that arise in real classroom situations. The modules equip teachers with the skills to prepare and enact lessons that will help students develop conceptual understanding of linear functions while strengthening teachers’ understanding of linear functions. (p. 38)

Moreover, the use of the regional K-12 curriculum framework organized the PA Academic Standards into big ideas at each grade level in an effort to build students’ conceptual understanding (Malik, 2004). It emphasized the notion the current mathematics curriculum is a mile wide and an inch thick.

With the use of research-based tools in the TLAs, participants reflected they gained a better understanding of how to support the development of a conceptual understanding of mathematics for their students (Williams et al., 2006). Furthermore, participants valued the role of collaboration in the TLAs. Williams et al. (2006) explained:

> the majority of the participant comments reflected an enhanced understanding of student thinking through research-based tools and curriculum-appropriate activities. Participants further expressed how much they enjoyed seeing the different ways their colleagues

> approached follow up session activities, and concluded that the tasks not only help them think about student learning, but about their own learning as well. (p. 28)

Participants also credited other aspects of the TLAs as being valuable. These included the topics of Tuning Protocol (a protocol for examining student work), formative classroom assessment and the analyzing instructional materials process (Williams et al., 2006). Moreover, many of the TLA participants “mentioned having acquired a tremendous amount of information related to content-embedded pedagogy, along with an increased awareness of how well they understood inquiry relative to other teachers, and their place in the district with respect to curriculum reform” (Williams et al., 2006, p. 28).

The TLAs and On-Site academies reflected the notion of teachers engaging in continuous professional development grounded in the real-world context of their classrooms and anchored within daily practice. The design and implementation of the TLAs was situated in research depicting the best practices of professional development. The existing literature identifies that professional development is most successful when it connects to content and student curriculum; moreover, teachers are provided with on-going time and focus to engage with content and pedagogy (Walker, 2007). The utilization of Teacher Leaders to provide the professional development to their colleagues supported the notion of building capacity of an organization by distributing leadership across different levels of the school (Steele, Pane, Williams & Olmsted, 2006). With administrative turn-over being so great in Southwestern PA, creating “vertical slices” of leadership amongst district leaders and teachers was necessary to sustain the standards-based mathematical instructional practices the MSP promoted.

2.3.3.3 On-Site Academy (OSA)

The On-Site Academies occurred as a result of the work of the LATs and district teacher leader participation in the TLAs. OSAs were professional development opportunities that occurred across the mathematics department. After a teacher's participation in the TLAs, the teacher returned to his or her district to conduct the same professional development received in the TLAs for their colleagues. These professional development activities occurred on the district campus, and the LATs were responsible for procuring the resources and time for the OSAs to occur. Beginning in the summer of 2006, 41 of 48 MSP districts conducted 106 On-Site Academies (Bunt, 2006). The goal of the MSP was for 24 hours of on-site professional development to be conducted in districts facilitated by Teacher Leaders; in 2004-2005, 14 OSAs met the goal, 27% met the goal with at least half of their participants participating in 20 hours of professional development, 37% of districts had 10-20 hours of professional development occur, and 38% of districts participated in fewer than 10 hours of professional development (Bunt, 2006). Each teacher in the TLAs had participated in 8 modules of professional development with each module consisting of approximately 3 hours (Bunt, 2006). For some districts, scheduling issues and competing initiatives resulted in a reduction of the number of hours On-Site Academies occurred (Williams et al., 2006). In these cases, the MSP Coordinators, Principal Investigator and K-12 Project Director intervened to meet with these administrative teams in order to secure and renew the commitment to providing the resources for these On-Site Academies (Williams et al., 2006).

As a result of participation in the TLAs and OSAs, teachers reported changes in instructional practices occurring from opportunities to engage in practices enhancing K-12 students' knowledge of math (Williams et al., 2006). Teachers reported increased awareness of research-based practices and increased content knowledge; furthermore, teachers reported that the professional development experiences provided slight to moderate emphasis on student learning and student needs (Williams et al., 2006). As discussed in the literature review, it is characteristics such as these that help to affect teachers implementing standards-based practices into their classrooms.

2.3.3.4 Content Deepening Seminars

The Content Deepening Seminars (CDS) were professional development opportunities designed to increase teachers' content knowledge in the areas of mathematics while also creating pockets of expertise within schools (Williams et. al., 2006). Within the CDS, vouchers and stipends were provided to support teachers to attend these seminars sponsored by IHE partners (Williams et al., 2006). The seminars were an opportunity to build capacity by increasing teachers' content knowledge; furthermore, the CDSs provided a menu of opportunities to participating districts to meet the specific needs identified by the district LATs (Williams et. al., 2006). Williams et al. (2006) explained:

> participation rates for teachers in the CDSs were relatively low. Of the nearly 700 available slots, only 178 teachers registered and of those only 137 from 29 districts actually attended. One explanation for this may be fatigue from other professional development activities. (Williams et al., 2006, p. 31)

The CDS served as a means to increase teachers' content knowledge and strengthen the partnership along the K-16 educational continuum, and the MSP of Southwestern PA continued to investigate ways to promote teacher participation in these CDS.

2.3.3.5 Lenses on Learning

Because administrative buy-in is essential to the success of the MSP, Principal Seminars became a requirement for a district's participation in the MSP project beginning with year two of the project. The Principal Seminars provided an opportunity to both raise awareness of administrators' perceptions of effective mathematics instruction while also engaging in the discourse of standards-based classrooms. Moreover, for sustainability of the professional development opportunities experiences of the TLAs and OSAs, principals were an essential component of this conversation for sustainability of standards-based practices to continue.

The primary tool of the MSP Principal Seminars consisted of *Lenses on Learning* (LOL) disseminated by the Educational Development Center (Williams et al., 2006). In this research-based program funded by the NSF, Williams et al. (2006) explained that principals were able to engage in the discourse of effective mathematical learning through the following:

> viewing math classrooms, analyzing research articles, and engaging in math explorations, participants are taught to rethink the observation-conference process, focusing on: student understanding of the mathematical content, teacher understanding of the mathematical content, student learning in the current class, the teacher's pedagogical practices, the nature of the classroom intellectual community, and the teacher's involvement in intellectual community outside of the classroom. (p. 32)

Lenses on Learning was the primary strategy for garnering administrative support of the MSP. Although it was offered since the inception of the MSP, it became a required activity for districts who wanted to become involved during the three year expansion of 2005-2006; moreover, since 2003, 81 districts and 315 administrators have participated in approximately 8,569 hours of *Lenses on Learning* professional development (Botkin, Adams & Price, 2009). It is through this program administrators had the opportunity to increase their awareness of effective mathematical instruction with a focus on both teacher and student discourse in the classroom. In addition, the activities promoted in *Lenses on Learning* helped to promote the standards-based instructional practices being touted in the TLAs and OSA.

3.0 METHODOLOGY

3.1 DESCRIPTION OF THE STUDY

Given the TLAs were designed using the research-based criteria, it was important to explore the career trajectories and personal experiences of teachers who have participated. It was also valuable to determine teachers' self-reported perceptions of the long-term use of the standards-based practices promoted in the TLAs after a significant time period has passed. Moreover, it was important to identify self-reported perceptions of potential barriers and supports teachers have encountered that may have contributed to the continued implementation of such standards-based practices. With the Standards for Mathematical Practice encapsulated in the PA Core, students are expected and required to engage in practices reflecting standards-based ideas. This requires teachers who are able to design and orchestrate different types of standards-based experiences for their students.

Specifically, using a mixed methods design, this study started by determining the career trajectories and professional experiences of teachers who participated in the TLAs in regard to their current role and district. According to Mertens (2007), the use of a mixed methods design employing both quantitative and qualitative research traditions "can be used to answer questions that could not be answered in any other way" (p. 294). This study utilized both qualitative and quantitative methods. Moreover, this study engaged a sequential explanatory strategy. The use of a sequential explanatory strategy "is characterized by the collection and analysis of quantitative data in the first phase of research followed by the collection and analysis of qualitative data in the second phase that builds on the results of the initial quantitative results" (Creswell, 2007, p. 211). In this study, quantitative data were collected using surveys while the qualitative data of the semi-structured interviews added greater clarity and depth to the analysis of the survey data. As schools begin to integrate the PA Core Standards and the Standards for Mathematical Practice, developing an understanding of the barriers and supports assists administrators in the promotion and sustainability of the types of instructional practices supporting the Standards for Mathematical Practice.

3.2 STATEMENT OF THE PROBLEM

3.2.1 CONTEXT OF THE PROBLEM

The enactment of the Common Core Standards and the PA Core Standards calls for teachers to implement both content and process standards in mathematics. The Standards for Mathematical Practice require students in grades pre-kindergarten to grade twelve to engage in process standards through the following:

1. Making sense of problems and persevere in solving them.
2. Reasoning abstractly and quantitatively.
3. Constructing viable arguments and critique the reasoning of others.
4. Modeling with mathematics.

5. Using appropriate tools strategically.
6. Attending to precision.
7. Looking for and making use of structure.
8. Looking for and making sense of regularity in repeated reasoning

Implementation of the process standards suggests the use of standards-based instructional strategies. Because this may be a change of practice for some teachers, the use of these types of instructional strategies requires professional development that is on-going, sustained, centered upon content, and anchored in a teacher's professional practice (Briars, 1999; Hill, 2004; Walker, 2007). The MSP TLAs were designed to reflect such characteristics; furthermore, the TLAs were also designed to reflect the best practices for adult learning. Because the PA Core Standards for Mathematical Practice convey tenets of standards-based mathematics, it was valuable to explore if teachers who participated in the TLAs continue to implement standards-based practices in their classrooms now even after a significant time period has passed since the professional development occurred. Additionally, this study examined teachers' self-reported perceptions of barriers and supports in schools and districts that may have affected the continued use of standards-based instructional practices over time. For administrators, it also identified potential barriers and supports for this type of professional development which may contribute to the conversation as administrators work to engage their teachers in the use of standards-based mathematical strategies.

3.2.2 STUDY QUESTIONS

The MSP Logic Model is a useful theoretical framework in considering the implementation of standards-based instructional strategies occurring within classrooms (See Figure 1). The logic model depicts the implementation of MSP strategies such as the TLAs after the interventions occurred. It does this by depicting the short-term, mid-term and long-term outcomes which occur as a result of the intervention strategies.

This study reflects the logic model by its focus on teachers' perceptions of the long-term use of standards-based instructional practices occurring in K-12 classrooms and its focus on teachers' perceptions of barriers and supports contributing to the use of standards-based practices over time. The guiding research questions captured teachers' perspectives of what standards-based instructional practices are currently being implemented in their classrooms, and if so, to what extent (*none, less than 10% of time, 10%-25% of time, 26%-50% of time, 51%-75% of time,* or *more than 76% of time*). The study also gathered information related to potential barriers and supports affecting the use of standards-based instructional practices.

Perspectives were gathered from teachers who have participated in the MSP's Secondary Mathematics Teacher Leadership Academies from 2004 to 2008. These participants were asked to self-report if specific standards-based instructional strategies occurred in their classrooms and the frequency of the practices. Furthermore, participants were asked to self-report about potential barriers and supports they have encountered which may have affected the implementation of the standards-based practices in their classrooms. The barriers and supports were classified according to one of three dimensions: technical, political and cultural (Anderson, 1996). The three dimensions served as the conceptual framework for the barriers and supports section of the survey. In addition, this framework also served as the basis for the semi-structured interviews. This study served to answer the following research questions:

1. What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?

2. What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?

3. For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?

3.3 RESEARCH METHODS AND DESIGN

3.3.1 POPULATION AND SAMPLE

The population for this study consisted of all teachers who have participated in the Southwestern PA MSP's secondary mathematics TLAs beginning in 2004 through 2008. The sample for this study was a convenience sample because the researcher attempted to collect data from whoever was available or was able to be recruited from this population to participate in the study (Huck, 2012). To formulate the sample for this study, the researcher began by identifying all teachers who participated in the MSP TLAs from 2004-2008. According to Volume 14 of the Math & Science Collaborative' s *Journal*, this translated into an initial population size of 165 individuals.

This publication which provided this information can be found online at the following website: http://www.aiu3.net/Level3.aspx?id=9850. The initial population size was reduced to 164 as a result of excluding the researcher from the sample. Once the individuals were identified, the population was further influenced by including only those individuals who had available contact information.

Of the 164 teacher participants of the MSP TLAs, current contact information (email addresses) was identified for 121 teachers (73.3%, n=165). To determine current contact information, the researcher conducted thorough internet searches using school district websites in conjunction with other websites such as Linked In, Rate My Teacher, and PA Public Schools Salaries. To account for name changes of teachers since their participation in the TLAs, the researcher also searched the Allegheny County Marriage Records Department. Through the multiple data sources, the researcher was able to locate email address information for approximately 73% of the original participants. Given this initial sample size of 121 participants, the possibility of a small number of participants actually completing the survey still existed because of factors such as retirements, teacher mobility and attrition. This concern is addressed in the limitation section.

The researcher originally provided the survey to the 121 teachers (teachers with current contact information) who participated in the TLAs from 2004-2008. For those teachers who are no longer employed with the same district, the researcher attempted to search for them to provide them with the opportunity to participate in this study. To locate the individuals, the researcher searched for these individuals online to identify their current district placement and assignment. When current contact information was unable to be located, this was reflected in response to research question one.

3.3.2 METHODS

Using a mixed methods design, this study was divided into two data collections: survey and semi-structured interviews. In selecting the mixed methods design, it was the researcher's intent "to seek a common understanding through triangulating data from multiple methods" (Mertens, 2010, p. 294). The survey was used to garner the quantitative data, and the semi-structured interviews were used to capture qualitative data that provided a more descriptive context to the quantitative survey data.

The survey was administered to the sample of 121 teachers (with current contact information) who participated in the MSP's secondary mathematics TLAs beginning in 2004 to 2008. In the survey, participants were asked to indicate if they would be willing to participate in the semi-structured interview portion (Phase 2) of the study. Of the respondents, seven participants indicated they would be willing to participate in the semi-structured interviews. Follow up contact was made with these individuals through both email and phone calls. Three emails were sent asking to confirm participation in the semi-structured interviews; one follow up phone call was also made to confirm participation. Of the seven respondents who initially indicated their willingness to participate in the semi-structured interviews, four individuals confirmed their willingness and agreed to be interviewed.

3.3.3 CONCEPTUAL FRAMEWORK AND SURVEY DESIGN

The conceptual framework for this study drew upon two sources: a review of the literature on what constitutes standards-based mathematical instructional practices and the identification of barriers and supports that contribute to the sustainability of such practices. Because of the alignment of the survey questions to the Surveys of Enacted Curriculum (SEC) to standards-based instructional practices, the SEC was chosen as the basis for assessing the use of these practices. The conceptual framework used in identifying the barriers and supports contributing to the sustainability of such practices draws from the classification of barriers and supports into one of the following dimensions: technical, political or cultural (Anderson, 1996). Further, data regarding the use of standards-based mathematical instructional practices and identification of barriers and supports contributing to the long-term use of such practices were also gleaned through the semi-structured interviews. It is the blending of these two components that served as the framework for this study.

The first data collection instrument for this study was an online survey administered to participants via Survey Monkey; moreover, this survey represented a simple descriptive approach at capturing the characteristics of a particular sample at one specific point in time (Mertens, 2010). The structure of the survey consisted of five sections: Demographic Information, School and Target Class Description, Instructional Practices, Assessment Practices, and Barriers/Supports. The design for Sections I, II, III & IV (Demographics, School and Target Class Description, Instructional Practices and Assessment Practices) stemmed primarily from the SEC which was designed by the Council of Chief State School Officers (CCSSO). Section V, Barriers/Supports, was based upon the conceptual framework of Anderson's (1996) *Study of Curriculum Reform*. In this section, the barriers and supports were studied through three different dimensions: technical, political or cultural (Anderson, 1996).

3.3.3.1 Surveys of Enacted Curriculum (SEC)

For the development of the SEC survey, CCSSO partnered with Andrew Porter and John Smithson of the Wisconsin Center for Education Research "to develop an advanced, in-depth approach to collecting and reporting data on the 'enacted curriculum' in K-12 math and science, i.e., the actual subject content and instructional practices experiences by students in classrooms" (Council of Chief State School Officers, 2005). The SEC was developed and tested in several studies; in 2001, it was tested in a major study that consisted of over 400 schools in 11 states (Blank, 2002). The SEC asks teachers to self-report on different areas such as instructional practices and activities, assessments, instructional influences, classroom instructional readiness, teacher opinions and beliefs, professional development, teacher characteristics, formal course preparation, and demographic information of the school and class. In addition, the SEC also addresses specific instructional content areas for mathematics. Data collected through the SEC is self-reported by teachers; however, an in-depth comparative study comparing self-reported survey data to other data collections methods such as observations and logs show that "survey results have a high degree of consistency with results from other methods, and they have the enormous advantage of low costs for a large sample" (Blank, 2002, p. 92).

The rationale for utilizing selected sections of the SEC stemmed from the inclusion of instructional practices reflecting standards-based mathematical instructional practices. According to the CCSSO (2005), "the major concepts underlying the designs for the Surveys were drawn from state and national content standards, state initiatives in science and mathematics education, and prior research studies on classroom instructional practices and curriculum content" (p. 3). The SEC surveys are based upon state and national standards for content as well as examples and other tested items on survey instruments such as the TIMSS, NAEP, and National Survey of Science and Math Education (CCSSO, 2005).

Furthermore, this study investigated the utilization of standards-based instructional strategies in mathematics classrooms after participants have received professional development experiences considered to be high-quality (MSP TLAs). The design of the SEC encompasses the six criteria for high-quality professional development: content focus, school based, active learning, extended time, follow-up, coherence and the connection to other activities (Blank, 2002). These six criteria echo the same ideas as reflected in the literature review pertaining to high quality professional development experiences. Because this study explored the utilization of standards-based instructional practices after participation in high-quality professional development, both the design and the alignment of the questions on instructional practices and assessment reflected research question two for this study. In addition, the SEC or a modified version of the SEC has been used with numerous MSP projects including the MSP of Southwestern PA, the MSP of SUNY Brockport, the MSP of Cleveland Municipal School District, the El Paso Math and Science MSP and the MSP of South Texas AIMS PreK-16 (Smithson & Blank, 2006).

As a component of the evaluation plan for the MSP of Southwestern PA, the SEC survey was selected because of its ability to measure the types of instructional practices advocated by MSP interventions, such as the TLAs; moreover, the survey itself was revised to reflect those items relevant to the MSP intervention strategies (Williams, Pane, Tananis & Olmsted, 2005). Because of the alignment of this survey to mathematical instructional practices aligned to the MSP professional development experiences, this survey was chosen for this study to capture and evaluate teachers' perceptions of the instructional mathematical practices occurring in their classroom that exist after their work with the TLAs.

As with the modified SEC used with the Southwestern PA MSP, this study also used a modified version of the SEC. This modified version consists of Demographic Information, School and Target Class Description questions, Instructional Practice questions and Assessment questions. For this study, the survey questions included have been extracted from the SEC's sections on Demographics and Instructional Practices. The MSP of Southwestern PA also administered a modified version of the SEC to mathematics teachers (Williams, Pane, Tananis & Olmsted, 2005). This modified version was also referenced in the design of this study; moreover, the questions used in this study's survey primarily reflected the questions of demographics and instructional practices used in the modified MSP SEC survey. For the purposes of this study, in addition to its use by the Southwestern PA MSP, a modified version was selected due to the lengthy nature of the original SEC. According to the CCSSO (2005), the complete SEC survey requires an average of 1.5 hours for completion (CCSO, 2005). It is due to the survey's lengthiness that modified versions were utilized for the MSP of Southwestern PA's evaluation plan; moreover, a modified version was also utilized for this study.

The researcher received permission from the authors of the SEC to use and modify this survey for this study (See APPENDIX B). Specifically, the SEC was chosen as it provided alignment to the second research question in this study; however, the researcher chose to modify the questions in an effort to better address the research questions of this study. Since this study also explored the career trajectories and professional experiences of participants of the TLAs, questions were included in the survey to address this. The questions occurred in the demographic section.

Furthermore, some participants who participated in this study are no longer classroom teachers. As a result, questions pertaining to the use of instructional and assessment practices may no longer be appropriate. To address this, the survey branched into two different directions. If the participant indicated they provided mathematics instruction during the 2012-2013 school year, then these individuals were directed to complete the questions related to Instructional Practices, Assessment Practices and Barriers and Supports. If the participant did not provide mathematics instruction during the 2012-2013 school year, then they were directed to identify information as to if and how their work in the MSP TLAs may have affected their current work in their current role.

3.3.3.2 Barriers and Supports

The Barriers and Supports Section of this study's survey drew upon the work of Anderson's (1996*) Study of Curricular Reform*. Anderson's framework was chosen to study the barriers and supports for standards-based instructional strategies occurring both at the school and system level. This section of the survey drew upon the study of *Effective Professional Development and Changes in Practices: Barriers Science Teachers Encounter and Implications for Reform* (Johnson, 2006). The creation of the questions in this section of the survey also stemmed from personal experiences in the K-12 education sector.

Each of the survey questions included in Barriers and Supports Section was aligned to one of the following dimensions: technical, political or cultural. The technical dimension includes "teacher content knowledge, pedagogical knowledge and the teachers' ability to teacher constructively and implement reform" (Johnson, 2006, p. 152). According to Anderson (1996), the technical dimension focuses upon the knowledge and skills a teacher needs to enact the reform and the means by which the teacher acquires this knowledge within the reform context.

Each of the areas identified in the technical dimension may have contributed as a support or barrier of the long-term use of standards-based instructional strategies implemented within the classroom. In addition, the review of the literature indicates that professional development experiences that affect teacher practice address both content and pedagogical knowledge (Darling-Hammond, 1998; Hill, 2004; Walker, 2007). Each of the dimensions was addressed in this section of the survey.

In the Barriers and Supports Section of the survey, the following survey items reflected the technical dimension: content knowledge, pedagogical knowledge, the role of the textbook, current scheduling practices (traditional scheduling, block scheduling), role of standardized assessments (PSSAs, Keystones, AP exams), instructional time, planning time, role of authentic assessments, in-service opportunities, role of teacher and role of student (Anderson, 1996: Johnson, 2006). Much of the emphasis for professional development that supports the inclusion of standards-based teaching practices rests on both content knowledge and pedagogical knowledge and stems from this technical dimension. According to Johnson (2006), "if the teacher has strong content and pedagogical background, reform efforts are more likely to succeed" (p. 152). In addition, as Loucks-Horsley & Matsumoto (1999) argued, content knowledge is key in knowing how to teach students the subject matter for understanding; moreover, "knowledge of children, their ideas, and their ways of thinking is crucial for teaching for understanding" (p. 262). Further, the technical dimension is essential to execution of standards-based practices as "the new pedagogical approaches are more diverse, their demarcation from traditional practice less apparent, and their acquisition by practitioners more complicated" (Anderson, 1996, p. 42). Because standards-based practices typically require a shift in thinking, the inclusion of survey questions addressing the technical dimension was essential.

Within the survey, the political dimension was also addressed in the Barriers and Supports Section. In the political dimension, "the primary political barrier for teachers is the lack of school or district leadership and support" (Johnson, 2006, p. 152). The barriers and supports in this dimension are comprised of local leadership and support, resources, collaboration and in-service training; furthermore, this dimension also attends to authority, power and influence (Anderson, 1996; Johnson, 2006). This dimension was addressed by asking participants about collaboration, departmental expectations, leadership and leadership support, parental support, curriculum, resources, the role of tracking for students and professional development.

The final dimension in this framework consisted of the cultural dimension. Anderson (1996) explained:

> values, beliefs, and school norms—both in terms of a general ethos and competing perspectives that war with each other—have a powerful influence on what reforms are sought in a given case, as well as a powerful influence on how readily the reform can be made and what form it actually takes in school practice. (p. 47)

For example, if teachers believe the key to students learning mathematics is through drill and practice, then these beliefs present an obstacle to the inclusion of standards-based instructional strategies in their classroom (Johnson, 2006). Moreover, the idea of "preparation ethic" is a barrier existing in many secondary classrooms. According to Anderson (1996), preparation ethic is "the idea that the accumulation of fairly discrete knowledge and skills, rather than critical thinking skills, will prepare students best for the next level of schooling" (p. 59). This idea of having to cover all the material in preparation for the next grade level can exist among secondary teachers; this idea is even further heightened today because of the emphasis on high stakes assessments. The Barriers and Supports Section of the survey addressed the cultural dimension by asking to teachers to respond to questions addressing their beliefs about teaching, the curriculum, learning and the role and value of the collaboration in the work of teaching.

Certainly, the elements contained in this survey were not restricted to one dimension. Prior to the execution of this study, the researcher categorized the survey items into the category best reflective of the dimension based upon Anderson's definition. For example, providing in-service time for teachers to develop their content and pedagogical knowledge speaks to the technical dimension; however, the in-service opportunities may also work to change the values and beliefs of teachers of why a change in practice is needed. As a result, this particular example may be reflective of two dimensions, technical and cultural. Although barriers and supports may exist in multiple dimensions, it is essential to provide attention to all three dimensions. Anderson (1996) indicated:

> a systemic perspective is of great importance and care must be exercised to see that no important factor is ignored. The search should not be for the one key ingredient; the search should be for the inclusion of all the essential ingredients—and putting them together in a manner that takes account of the systemic nature of the situation. (p. 61)

The implications of the connections between dimensions are discussed more thoroughly in the analysis and reporting of the data; moreover, the researcher explored these connections more deeply through the semi-structured interviews that occurred with a subset of participants.

In summary, the different sections in this survey aligned with each of the research questions. Demographic Information and Target Class Information was included in this survey to address research question one; moreover, the comprehensive search of current contact information of participants also addressed research question one. In addition, this information assisted the researcher in gaining a more comprehensive picture as to factors that may have contributed to how participants responded to different items within the survey. Research question two was addressed by the Instructional Practice and Assessment Practices Section of the survey, and the final research question was addressed by the Barriers and Supports Section.

3.3.4 PILOT SURVEY

Prior to administering the survey to the sample of 121 participants, the survey was piloted with two different groups. The first of the pilot testing occurred with approximately 10 members of the dissertation study group. These individuals provided a substantial amount of feedback on the navigability, structure, readability and timing of the initial survey, and the suggestions were used for revisions.

After this initial pilot and subsequent revisions, the survey was piloted again. This second pilot occurred primarily with mathematics teachers who were not included in the sample of this study. During this second pilot (which occurred during the summer of 2013), the revised survey was administered to six mathematics teachers and one high school administrator. Of the six mathematics teachers contacted, four teachers completed the survey and provided additional feedback. The high school administrator also provided feedback. The feedback provided from each group was used to make additional revisions to the survey. The final survey was again revised using the feedback and comments of the individuals who participated in each of these pilot administrations.

3.3.5 SEMI-STRUCTURED INTERVIEWS

During the survey, participants were asked if they would be willing to participate in the semi-structured interview portion of this study. If the participant indicated their willingness to participate in the interviews, then they were also asked to provide their contact information. From the survey, seven participants initially indicated their initial willingness to participate in the semi-structured interviews. Multiple communication attempts (both email and phones calls) were made to confirm interview participation. After all recruitment communications were completed, interviews were scheduled with four of these initial seven respondents (57.1%, n=7). The interviews occurred during the month of November 2013 which was approximately one month after the survey was administered.

As the semi-structured interviews occurred, they were recorded and later transcribed. Prior to the recording of the interviews beginning, participants were asked for consent to be recorded. Once recording started, participants were again asked to indicate their consent to be recorded. Upon completion of the interviews, interviewees were given the option to review the transcripts of the interviews for accuracy. Two of the four interviewees asked for copies of the interview transcripts. Such transcripts were provided to the individuals in December 2013.

The questions and probes for the semi-structured interviews were developed from both the literature and personal experiences. In reviewing the literature, common characteristics of what defines standards-based mathematical instructional practices emerged, and these characteristics informed the interview questions. Furthermore, in reviewing the literature, different barriers and supports also emerged. The barriers and supports were then classified into one of the following dimensions: technical, political and cultural. They also served to inform the interview questions. The questions and probes have been aligned to the literature and the research questions; the table depicting the alignment to both the literature and research questions for the semi-structured interviews is available in APPENDIX C**.**

3.4 DATA COLLECTION AND ANALYSIS

Both quantitative and qualitative methods were used to analyze the data. The survey data were analyzed using quantitative methods; the qualitative data captured from the semi-structured interviews added a greater context to the descriptive statistics captured in the survey. The career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs were documented using both quantitative and qualitative data, and this was also described in a narrative and tabular form. To determine the contact information for the individuals who were included in the sample for the survey, these data were collected first and are presented for the data reporting of research question one.

In the survey, the quantitative data analysis identified the frequency of self-reported standards-based instructional practices utilized in teachers' classrooms while identifying potential self-reported barriers and supports that have affected the continued utilization of standards-based practices. These data were collected, entered and analyzed through the online web-based tool of Survey Monkey; moreover, after the data was collected, it was entered into the statistical tool of SPSS. Using SPSS, the researcher was able to provide and analyze the descriptive statistics for the survey items. According to Rea & Parker (2005), “measures of central tendency and measures of dispersion constitute the fundamental elements of what is known as descriptive statistics because they describe and summarize vast amounts of data by the use of single statistical values” (p. 99). Because the data collected within the survey is nominal and ordinal data, the only measure of central tendency appropriate for reporting is mode; computing the measures of mean and median for nominal and ordinal data are meaningless (Lavrakas, 2008). As a result, modes for the frequency distribution tables have been reported. Frequency tables and contingency tables were also reported and used to disaggregate responses by specific variables. The specific variables include years of teaching experience and teacher leadership experiences.

For the survey data, chi-square tests were also performed on the appropriate data sets. The chi-square test was appropriate to use for this study due to the collection of nominal and ordinal data. According to Lavrakas (2008), “the chi-square (x^2) is a test of significance for categorical variables. Significance tests let the researcher know what the probability is that a given sample estimate actually mirrors the entire population” (p. 3). The chi-square test was performed to determine the relationships or non-relationships of the variables being investigated in this study.

The analysis of the barriers and/or supports was also reported using Anderson’s (1996) conceptual framework of the three dimensions: technical, political and cultural. Because some of the survey items captured components of multiple dimensions, this discussion was also pursued in the data analysis and reporting section. These data were analyzed both qualitatively and quantitatively. In addition, the researcher analyzed the data to determine if themes emerged in terms of the dimension most frequently noted for supports and the dimension most frequently noted for barriers.

The qualitative data collected through the semi-structured interviews were analyzed and coded for reoccurring themes. For the coding of the interviews, the researcher used the grounded theory model of allowing the codes to emerge during the data analysis (Rubin & Rubin, 2005). According to Rubin & Rubin (2005), the grounded theory model argues "coding, recognizing concepts and themes, and theory development are parts of one integrated process" (p. 221). Using two of the interviews, a codebook was developed, revised and refined to analyze the qualitative data of all the semi-structured interviews. This codebook was applied to all four semi-structured interviews and was revised throughout the process as needed. It is located in APPENDIX E. Using the qualitative data analysis software of Atlas.ti, the codebook was then applied to the coding the text of the interviews. After the coding process, clusters of codes were grouped together to create themes and subthemes.

The representation of the qualitative data occurred through the use of a narrative descriptions. These descriptions included a "detailed discussion of several themes (complete with subthemes, specific illustrations, multiple perspectives from individuals, and quotations)" that provided more depth and clarification to the previously collected survey data (Creswell, 2009, p. 189). The data collected in the semi-structured interviews were also cross-checked against the survey data in order to increase validity and triangulate results.

The results of this study may be used to make recommendations regarding how administrators can contribute to the sustainability of standards-based instructional strategies such as those demanded by Standards for Mathematical Practice. Such recommendations can inform the discourse between the Pennsylvania Department of Education, Math Science Partnerships, Intermediate Units, school districts, universities and other educational organizations. If students are to be engaged in the Standards for Mathematical Practice, then administrators and teachers benefit from an understanding of the barriers and supports that contribute to the sustainability of standards-based practices occurring in their classrooms.

3.5 PARTICIPANT RECRUITMENT AND RESPONSE RATE

After the researcher collected current contact information from participating teachers of the TLAs, the 121 participants were sent an introductory email with a link to the survey and invited to participate in the survey. This introductory email explained the study had two phases. Phase 1 of the study was the survey. During the survey, participants were asked to indicate if they would be willing to participate in the semi-structured interviews, Phase 2, of the study. After Phase 1 of the study was completed, then the researcher followed up with a subset of survey respondents to arrange the semi-structured interviews of Phase 2.

The introductory email explained the purpose of the study and identified any risks or benefits associated with it. Contained within this introductory email was also the link to the online survey itself. This introductory email was sent to participants on September 21, 2013. Of the initial 121 participants sent this introductory email, seven of the 121 were returned (5.7%, n=121). Of the seven returned, two were returned with the message “delivery has failed to these groups-the server has tried to deliver and will stop trying” and five others were returned due to the message being rejected. For the five returned due to the message being rejected, the researcher contacted their schools to verify the email addresses. The email addresses were verified and the researcher was notified two of the five individuals had retired. For the remaining three individuals, the email addresses were verified as correct by the schools, and the emails were again resent to the three individuals; however, they were still returned to the researcher with the same, original message.

Participants were provided with a window of approximately three weeks to complete the survey. The survey window closed October 11, 2013. On October 6, 2013, 109 participants were contacted with a follow up reminder. Participants who had completed the survey and whose contact information was identified somehow either through the survey (their gift card entry information or through their semi-structured interview contact information) were not sent the follow up reminder. The follow up reminder was sent to 109 individuals, and it notified them that the survey closed on October 11, 2013.

Prior to the follow up reminder being sent on October 6, 2013, only nine of the 114 individuals who received the initial invitation completed the survey. This translated into a low response rate of approximately 8% (7.9%, n=114). On October 6, 2013, participants received another reminder email regarding the survey. This reminder email clarified that participants did not have to currently teach mathematics in order to participate in the study, and it also reminded them of the opportunity to participate in the incentive gift card drawing. After this follow up email was sent, the participation rate increased to 25 individuals (21.9%, n=114); this translated into a response rate of approximately 22%.

Through an independent URL provided at the end of the survey, participants who completed the survey were able to enter themselves into a drawing to receive one of two $50 VISA gift cards. The explanation for this drawing was described in the introductory letter.

Participants were advised that the gift cards would be dispersed approximately two weeks after the close of the survey window. Gift card winners were chosen using random id numbers and an online random number generator; the gift cards were provided to the winners on October 28, 2013.

Because this study employed a sequential explanatory strategy, it was not possible to assure anonymity of the survey data; however, participants of this study were assured the data collected in this study was confidential data. Although some participants provided their name and contact information for consideration of inclusion in the Phase 2 portion of the study, participants were assured that the survey data collected was assigned a random ID number. The random ID numbers were the mechanism used to analyze the survey data. Contact information was only utilized to contact individuals who indicated their willingness to participate in the semi-structured interview portion of this study. This information was also contained in both the introductory and follow up emails sent to participants.

Participants were provided an approximate three week window for the completion of the online survey. One week prior to the close of the survey window, participants received a follow up email reminding them of the deadline for the survey. The follow up email thanked those participants who have already responded, reminded those of the approaching deadline and informed participants of the Phase 2 portion of this study. In addition, the follow up email contained information related to the incentive drawing for the $50 gift cards; the online survey closed two weeks after the follow up email was sent.

After the survey results were collected, the researcher used this information to determine the individuals who would be willing to participate in the semi-structured interviews. Seven respondents initially indicated their willingness to participate; however, after multiple communication attempts, the researcher was only able to confirm participation with four of the seven individuals. The semi-structured interviews were scheduled for approximately two to four weeks after the permanent closing of the survey window. All of the semi-structured interviews occurred during November 2013.

3.6 LIMITATIONS

Multiple limitations presented themselves through the course of this study. Because the data for this study was captured via teacher self-reporting, this may have caused some error to occur within the teachers' survey responses. Although the instructional practices described in the Surveys of Enacted Curriculum are described rather concisely, there still may have been some interpretation from teachers' perspectives that differ from the intent of the question. Different interpretations such as this may have caused for some type of error within the reporting data.

Furthermore, given the sample for this survey was a convenience sample of secondary mathematics teachers (grades 7-12) who participated in the Southwestern PA's MSP which occurred six to ten years ago, this resulted in a small sample. Certainly factors such as retirements, teacher mobility and attrition contributed to this and are represented in response to the first research question. Because this sample size was small, it is important that the researcher does not make generalizations based upon the data of this study. Due to the small sample size, the researcher used the semi-structured interview to garner rich and descriptive data related to the research questions of this study. The qualitative data collected clarified and expanded upon understandings gleaned from the survey data. Although the data cannot be generalized to larger groups and larger populations, the findings are still important as they contribute to the discourse of standards-based instructional practices.

Lastly, as a former participant of the MSP Teacher Leadership Academies, there is potential bias that this researcher may have contributed. As the researcher, I did my best to capture, report, code and analyze the data accurately and objectively. Recognizing my potential for bias in this study helped to create awareness for reporting and analyzing the data from the most objective perspective possible.

3.7 CONCLUSION

With the implementation of the PA Core Standards and the Standards for Mathematical Practice, now more than ever teachers are encouraged to utilize standards-based instructional practices in their classroom. The Standards for Mathematical Practice ask students to engage in practices such as constructing viable arguments, critiquing the reasoning of others, modeling with mathematics, and looking for and making use of structure in mathematics in addition to the five other process practices mentioned earlier. These reflect the tenets of standards-based practices. With such standards-based practices, students are active agents in their own learning; moreover, there is a strong emphasis on instruction in authentic contexts, making real-world connections, activity-oriented problem solving designed to promote a deep conceptual understanding (Hudson, Miller & Butler, 2006). Constructing, critiquing, and modeling require students to take an active role in their own learning. To accomplish this requires students who are self-directed learners who process information, interpret, explain and hypothesize, and share ownership for their responses (Anderson, 1996).

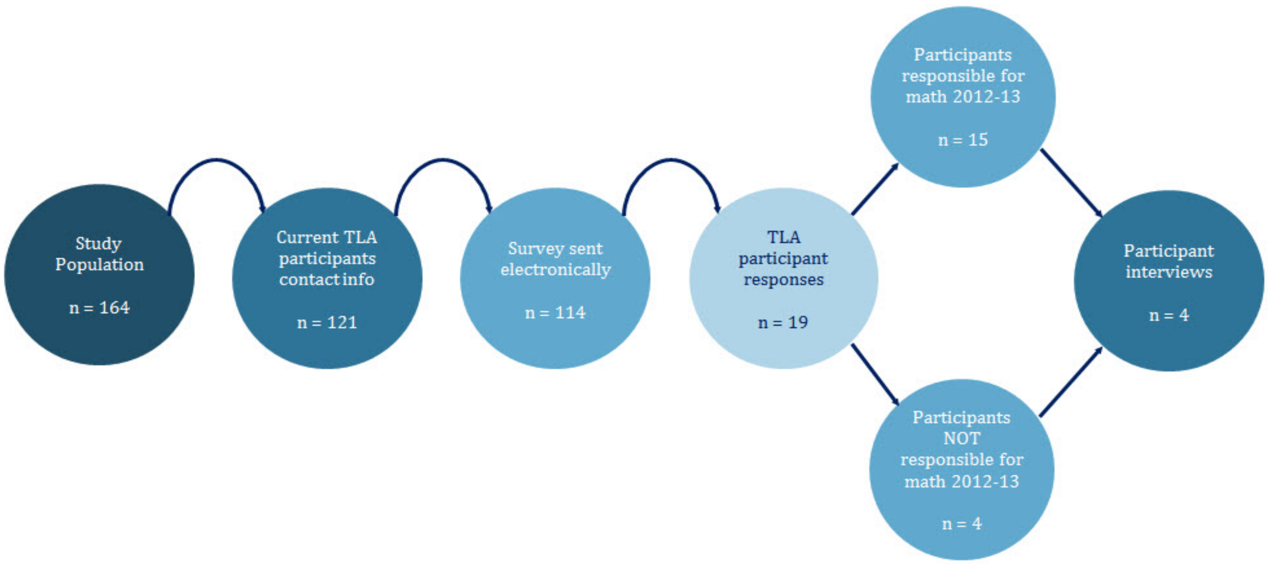
The data collected in this study may inform educators about the long-term use of standards-based instructional practices used after teachers participated in professional development experiences reflective of the characteristics the literature defined as more likely to affect change. In addition, this study has contributed to the discourse for administrators and other educators as to identifying barriers and supports that may contribute to the sustainability of standards-based instructional practices. If teachers are receiving the types of professional development experiences reflective of what the literature considers effective, then administrators and other educators should have an awareness of the barriers and supports that affect the sustainability of standards-based practices.

4.0 DATA PRESENTATION AND ANALYSIS

This chapter analyzes the data collected in this study which has been reported using frequency distribution tables for the survey data and descriptive narratives for the qualitative data. Because the data collected in the survey contained nominal and ordinal data, modes were used as the descriptive statistic to describe the frequency distributions. Furthermore, the chi-square test was performed for each of the data sets represented in the subsequent tables. The results of the chi-square test indicate no overall significance for the data sets; however, this may have occurred due to the nature of the small sample size for this study. Although there were no significant differences between the observed and expected frequencies for each of the data sets, results of the chi-square tests were summarized with the chi-square statistic, degrees of freedom and associated exact p-values and may be located in APPENDIX F. Overall, there were no significant statistical differences. Nevertheless, the most revealing information for this study stems from the descriptions of the frequency distributions and descriptive narratives of the semi-structured interviews.

The data for this study stems from multiple data collections. To answer the first research question, current contact information for TLA participants had to be obtained. Once this information was obtained, these individuals were administered the link to participate in the survey. Of those who responded to the survey (n=19), four participants indicated their willingness to participate in semi-structured interviews. For a visual representation depicting the study's population and sample, see Figure 2.

Figure 2: Study Population and Sample Flow Chart



4.1 DEMOGRAPHIC DATA

The chapter begins with a description of demographic data collected. As previously stated, 25 participants started Phase 1, the survey, of the study. Of the 25 participants, two participants completed only a few questions of the survey, and four participants were not provided the opportunity to complete the survey because they did not participate in the MSP TLAs. In order to ensure the sample only consisted of teachers who participated in the TLAs, participants were asked directly if they participated. If they indicated yes (n=19), then they were directed to the rest of the survey. Four individuals were directed to the end of the survey because they indicated they did not participate in the TLAs. Although the four individuals answered three demographic questions, their data has been excluded from the reporting since the individuals do not meet the criteria to be included in the sample. Given these constraints, the bulk of the data set is derived from 19 individuals. Although this is a relatively small sample, semi-structured interviews were also conducted (n=4) in an effort to gain a more comprehensive view of the data. Demographic information is reported for both the participants of the survey and the participants of the semi-structured interviews.

4.1.1 SURVEY DEMOGRAPHIC DATA

For the survey, 78.9% of respondents (n=15) were female; whereas, only a few of the respondents (21.1%, n=4) were male. In terms of race and ethnicity, a large proportion of the sample (94.7%, n=18) reported their race and ethnicity as white with one respondent (5.3%, n=1) reporting his/her race/ethnicity as other. For current position, 73.7% of respondents (n=14) indicated they were currently teachers; however, two respondents did not provide a response to this question. Of the 14 respondents who indicated their current position was a classroom teacher, eight (42.1%) indicated they were a mathematics teacher in the open-ended question asking them to describe their current role. Two teachers (10.5%, n=2) indicated they had additional teaching responsibilities beyond providing mathematics instruction. Such responsibilities included providing physics instruction and serving as the gifted teacher for grades 6-12. One respondent (5.3%, n=1) indicated she was currently a doctoral student/graduate assistant. Another respondent (5.3%, n=1) indicate she was currently a superintendent, and an additional respondent (5.3%, n=1) indicated she was a data analysis supervisor.

Prior to the 2013-2014 school year, respondents were asked to identify how long they: *taught mathematics, taught mathematics at their current school, held a teacher leadership position, held a building leadership position, held a district level leadership position, held a leadership position outside of the district (curriculum director at an IU).* They were provided with the following options: *none, 1 year or less, 2-5 years, 6-10 years, 11-15 years, 16-20 years* or *21 or more years.*

Table 2: Years spent in different roles/positions

Options	None		1 year or less		2-5 years		6-10 years		11-15 years		16-20 years		21 or more	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Taught mathematics	0	0.0	0	0.0	2	10.5	5	26.3	4	21.1	5	26.3	3	15.8
Taught mathematics at your current school	0	0.0	1	5.3	1	5.3	5	26.3	4	21.1	4	21.2	2	10.5
Held a teacher leadership position (i.e., department chair, curriculum leader, etc.)	7	36.8	3	15.8	4	21.1	4	21.1	1	5.3	0	0.0	0	0.0
Held a building level leadership position (assistant principal or principal)	18	94.7	1	5.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Held a district level leadership position (assistant superintendent, director, supervisor, superintendent)	17	89.5	1	5.3	1	5.3	0	0.0	0	0.0	0	0.0	0	0.0
Held a leadership position outside of a school district (i.e. curriculum director at an IU)	17	89.5	0	0.0	1	5.3	0	0.0	0	0.0	0	0.0	0	0.0

[1]Shading denotes the mode of respondents for a particular category.

A large number of respondents (89.5%, n=17) indicated they had anywhere from 6 to 20 years of experience teaching mathematics; moreover, 78.9% of the respondents (n=15) indicated they had been teaching mathematics at their current school for at least 6 years (See Table 2). Of the respondents, 10.5% (n=2) reported they had moved to a different school since the culmination of the TLAs; furthermore, 63.2% of the respondents (n=12) reported serving in some type of teacher leader position for at least some duration of time with 47.4% of respondents (n=9) serving in a teacher leader capacity for at least two years. Overall, 63.2% of respondents (n=12) reported having some type of teacher leadership position (department chair, curriculum leader) when compared to the respondents who reported no experience in this capacity (36.8%, n=7).

Beyond teacher leader positions, the overwhelming majority (94.7%, n=18) indicated they have not served in any type of building leadership position. Only one individual (5.3%, n=1) reported serving in this type of capacity. In examining district leadership experiences, 89.5% of respondents (n=17) reported no experience of this type. Two individuals (10.5%, n=2) reported serving less than 5 years of experience in a district level leadership position. One respondent (5.3%, n=1) indicated she had served two to five years in a leadership position outside of a school district such as a curriculum director at an IU.

In terms of educational background, 47.4% of respondents (n=9) indicated they earned their Bachelor's Degree in Mathematics Education (See Table 3). A number of respondents (31.6%, n=6) indicated they earned additional degrees in "other" field. The "other" field was defined to include education, science, history, English, and foreign languages. Of the total respondents, 73.7% (n=14) reported earning their Bachelor's Degree in some type of mathematics field (mathematics education, mathematics, or mathematics education &

mathematics). Furthermore, three individuals (15.8%) indicated multiple major fields of study for their Bachelor's degree.

Table 3: Major field of study for Bachelor's degree

Field of Study	n	%
Elementary Education	2	10.5
Middle School Education	1	5.3
Mathematics Education	9	47.4
Mathematics	3	15.8
Mathematics Education AND Mathematics	2	10.5
Other	6	31.6

Table 4: Highest degree

Degree	n	%
Bachelors (BA or BS)	4	21.0
Masters (MA, MS or MEd)	12	63.2
Masters Equivalency	2	10.5
Multiple Masters	1	5.3
Doctorate (PhD or EdD)	0	0.0
Total	n=19	100.0

In terms of highest educational degree obtained, 63.2% of participants (n=12) reported the highest degree they received was a Master's degree (See Table 4). Two participants (10.5%, n=2) reported earning their Masters Equivalency and one participant (5.3%, n=1) reported receiving multiple Master's degrees. In total, 78.9% (n=15) of respondents reported they pursued additional coursework beyond their Bachelor's degrees. None of the respondents reported earning their doctorate degree.

For additional coursework beyond a Bachelor's degree, 68.4% of respondents (n=13) reported they studied fields other than mathematics (See Table 5). These fields included educational leadership (31.6%, n=6) and "other" disciplines (36.8%, n=7). "Other" disciplines included other educational fields, science, history, English, and foreign languages. Furthermore, a number of respondents (36.8%, n=7) specifically identified the following fields for further study: business, computer science, instructional technology, general education and special education. Two respondents (10.5%, n=2) indicated they pursued additional coursework in the area of Special Education.

Table 5: Highest degree held beyond a Bachelor's Degree

Field	n	%
Elementary Education	0	0.0
Middle School Education	0	0.0
Mathematics	1	5.3
Mathematics Education	3	15.7
Mathematics Education AND Mathematics	1	5.3
Educational Leadership	6	31.6
Other	7	36.8

(*One respondent skipped this question.)

As far as certifications, 78.8% of respondents (n=15) reported receiving a secondary mathematics certification with 31.6% (n=6) indicating they received some type of administrative certification (See Table 6). This included curriculum and supervision certification, principal certification and superintendent certification. Of the respondents, 10.5% of the participants reported (n=2) earning an elementary or early childhood certification and another 10.5% of the participants (n=2) reported earning a special education certification. Approximately 16% of participants (15.8%, n=3) obtained middle school certification with the same number earning some type of secondary certification in a field other than mathematics. One of the respondents (5.3%) reported earning her physics certification and another respondent (5.3%, n=1) reported obtaining her National Board Certification. Ten individuals (52.6%) also indicated they had earned more than one type of state certification.

Table 6: Type of state certification

Type	n	%
Emergency or provisional certification	0	0.0
Elementary/Early childhood certification	2	10.5
Middle School certification	3	15.8
Secondary certification, in a field other than mathematics	3	15.8
Secondary mathematics certification	15	78.9
Special education certification	2	10.5
Administrator certification (i.e., curriculum and supervision, principal, superintendent)	6	31.6
National Board Certification	1	5.3
Other	1	5.3

(*One respondent skipped this question.)

4.1.2 SEMI-STRUCTURED INTERVIEW DEMOGRAPHIC DATA

For the Phase 2 portion of this study, semi-structured interviews were conducted with four teachers. Each of the teachers interviewed currently has some responsibility for providing mathematics instruction. One of the teachers is responsible for providing Physics instruction in addition to mathematics instruction. The remaining three teachers interviewed were solely responsible for providing mathematics instruction. Demographic information describing the interview participants and their current schools is provided in Table 7.

Table 7: Semi-structured interview participants

Teacher	District Enrollment	Setting	Years of Teaching Experience
A	2588	Suburban; Grades 9-12	24
B	3823	Urban; Grades 9-12	17
C	875	Urban; Grades 6-12	14
D	2452	Rural; Grades 9-12	8

4.2 SURVEY'S TARGET CLASS DESCRIPTION

To address the potential of the variance of roles and positions for survey participants, the survey branched into two pathways. After responding to demographic questions, participants were asked to indicate if they provided mathematics instruction during the 2012-2013 school year. If a respondent indicated she provided mathematics instruction during this time, then she was asked additional questions collecting descriptive information regarding her school. Additional descriptive questions were also asked in order to obtain information on the target class the individual would be referencing when answering questions related to mathematics instructional and assessment practices used during the 2012-2013 school year. Those who were not responsible for providing mathematics instruction during the 2012-2013 school year were asked to complete a different set of questions addressing their career trajectories and how their experiences in the TLAs may have influenced their work in their current role. Four respondents (21.1%) indicated they were no longer directly responsible for providing mathematics instruction. Fifteen respondents (78.9%) reported responsibility for providing mathematics instruction during the 2012-2013 school year.

In the survey instructions, participants were directed to choose a single mathematics class they taught during the 2012-2013 school year as the basis for their answers to some of the questions in the survey. This was defined as the target class. If the participant taught more than one mathematics class during this time, they were directed to use the first mathematics class of the week as their target class. If they taught both required and elective classes, they were directed to choose a required class as the target class. The target class was used as their point of reference for the survey questions addressing mathematical instructional and assessment practices and questions addressing the potential barriers and supports of such practices.

4.2.1 SCHOOL DESCRIPTIVE DATA

Respondents were asked to provide some data describing both their school and the target class. The majority of respondents (93.3%, n=14) indicated classes at their school were organized by departments (See Table 8). Two respondents (13.3%) indicated classes were team taught. Team teaching was defined as two teachers who both were responsible for providing instruction; whereas, one respondent (6.7%) reported that she was self-contained and provided instruction to multiple subjects. Two respondents (13.3%, n=2) also identified multiple descriptors for the organization of their target class. Moreover, 66.6% of respondents (n=10) indicated they instructed between one and three different mathematics class (See Table 9). Four additional respondents (26.6%) reported they instructed five and six different mathematics courses.

Table 8: Organization of classes in school

Description	n	%
Departmentalized Instruction	14	93.3
Self-contained (i.e. teacher of multiple subjects)	1	6.7
Team taught (i.e. two teachers providing instruction)	2	13.3

Table 9: Number of different mathematics courses taught

Number of different mathematics courses	n	%
1	2	13.3
2	5	33.3
3	3	20.0
4	0	0.0
5	2	13.3
6	2	13.3

(*One respondent skipped this question.)

Participants were also asked to describe factors considered to be most important when students were scheduled into the target class (See Table 10). The following options were provided: *ability or prior achievement, limited English proficiency, teacher recommendation, parent request, student decision,* or *other*. Of the total respondents, 78.6% (n=11) identified multiple factors of importance.

Table 10: Most important factors when scheduling students into the target class

Factor	n	%
Ability or prior achievement	12	80.0
Limited English Proficiency	0	0.0
Teacher recommendation	9	60.0
Parent request	0	0.0
Student decision	5	33.3
No one factor is more important than the other	1	6.7
Other	2	13.3

(*One respondent skipped this question.)

The most frequently (80.0%, n=12) cited factor was ability or prior achievement with teacher recommendation (60.0%, n=9) cited as the second most frequent consideration. Student decision was also identified as a factor for some (33.3%, n=5) in terms of scheduling students into the target class.

4.2.2 TARGET CLASS DESCRIPTIVE DATA

To develop an understanding of the target class being referenced in the survey, participants were asked to provide descriptive information about the class. Such details included the type of class, the duration of the class and student achievement levels of the majority of students in the class. Respondents were first asked to identify the best descriptor of the target class they were referencing. The following options were provided: *Middle school Math, Pre-Algebra*, *Algebra, Integrated Math, Geometry*, *Trigonometry, Advanced Math* or *Calculus.*

Table 11: Description of target class

Course	n	%
Middle School Math	3	20.0
Pre-Algebra	1	6.7
Algebra	5	33.3
Integrated Math	0	0.0
Geometry	2	13.3
Trigonometry	3	20.0
Advanced Math	1	6.7
Calculus	0	0.0
	n=15	100.0

The largest number of respondents (33.3%, n=5) reported Algebra best referenced the target class they were describing (See Table 11). In addition, there were a few respondents (20.0%, n=3) that chose both middle school math and Trigonometry as the best descriptor of the target class.

Table 12: Grade level majority of students in the target class

Grade Level	n	%
5th grade or below	0	0.0
6th	0	0.0
7th	2	13.3
8th	2	13.3
9th	3	20.0
10th	1	6.7
11th	6	40.0
12th	2	13.3

Table 12 describes the majority grade level of students for the target class. One respondent (6.7%) indicated multiple grade levels for her target class. Eleventh grade (40.0%, n=6) was the most frequently cited grade level with ninth grade (20.0%, n=3) referenced the second most frequently. In addition, 26.7% of the students (n=4) who comprised the target class were seventh and eighth graders.

Respondents were also asked to describe achievement levels of the majority of students in the target class relative to incoming/previous PSSA or Keystone scores (See Table 13).

Table 13: Achievement levels

Performance Level Description	n	%
Advanced	4	26.7
Proficient	5	33.3
Basic	6	40.0
Below Basic	0	0.0
Mixed Achievement Levels	0	0.0
	n=15	100.0

The achievement levels most often reported were advanced or proficient (60.0%, n=9). The remaining achievement levels (40.0%, n=6) were described as basic.

As far as timing of the target class, respondents were asked questions related to how often and how long the target class met. For the 2012-2013 school year, they were asked to identify how many weeks the target class met, how many hours per week the target class spent in mathematics class, and the average daily length of the target class (See Table 14, Table 15 & Table 16).

Table 14: Total weeks the target class met during the 2012-2013 school year

Total Weeks	n	%
1-12	0	0.0
12-24	1	6.7
Over 25	14	93.3
	n=15	100.0

Table 15: Hours target class spend in mathematics class per week

Hours	n	%
0-1	0	0.0
2-3	5	33.3
4-5	9	60.0
6-7	1	6.7
8-9	0	0.0
	n=15	100.0

Table 16: Average length of class period for the target class

Length	n	%
Less than 30 minutes	0	0.0
30-39 minutes	1	6.7
40-49 minutes	13	86.6
50-59 minutes	0	0.0
60-69 minutes	1	6.7
Over 70 minutes	0	0.0
	n=15	100.0

The majority (93.3%, n=14) of the target classes referenced met for over 25 weeks during the 2012-2013 school year (See Table 14). In addition, during the course of a week, 60.0% of respondents (n=9) reported spending 4-5 hours per week in mathematics class with another 33.3% (n=5) reporting 2-3 hours were spent in mathematics class (See Table 15). The average length of the class period typically fell within the 40-49 minute range (86.6%, n=13) (See Table 16). One respondent (6.7%) reported the target class met for 30-39 minutes, and another respondent (6.7%) reported the target class met for 60-69 minutes.

4.3 RESEARCH QUESTION #1

The first research question the findings of this study addressed is ***"What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs.*** After searching for current contact information of former TLA participants, the researcher was able to locate 121 teachers (73.8%) with 43 teachers (26.2%) lacking current contact information (See Table 17).

Table 17: Contact information for MSP TLA participants

Description	n	%
Able to locate current contact information	121	73.8
Unable to locate current contact information	43	26.2
	n=164	100.0

Using school district websites and other data bases, an analysis was performed examining the current role/position of individuals since their time of participation in the TLAs. This included examining current positions. Such categories used to classify individuals included classroom teacher (high school, middle school and elementary), gifted teacher, administrator, IU employee, dual roles, other and unable to locate (See Table 18). The dual roles category was comprised of individuals who were responsible for mathematics instruction as well as additional instructional responsibilities for other content areas. The other category included special education teachers, science teachers and computer teachers. It also included TLA participants who serve as technology directors, athletic directors, gifted program directors, district math coaches and graduate assistants at universities.

Table 18: Current role/position of MSP TLA participants

Position	n	%
Mathematics teacher	9	5.5
High school mathematics teacher	52	31.7
Middle School mathematics teacher	31	18.9
Elementary	5	3.0
Administrators	4	2.4
IU employee	1	.61
Other	15	9.1
Dual Roles	4	2.4
Unable to locate	43	26.2
	n=164	100.0

According to the information analyzed, 58.5% of the TLA participants (n=96) still continue to be responsible for providing some type of mathematics instruction to students at the secondary level. For those falling into the "other" category, a number of these individuals are special education teachers (3.0%, n=5) or science teachers (2.4%, n=4) with a few individuals (1.8%, n=3) serving their districts in some type of director capacity such as a technology director, athletic director, gifted program director or data analysis supervisor. A few participants (2.4%, n=4) have additional responsibilities (dual roles) in addition to their mathematics instructional responsibilities. Such additional assignments include gifted education, computer education and director of athletics.

As far as administrative positions, a small percentage of the TLA participants (2.4%, n=4) serve in some type of administrative capacity. Three of the TLA participants (1.8%) are currently identified as some type of building level principal with two (1.2%) serving as secondary principals. One individual is currently identified as a building level principal of a primary school. The only TLA participant serving in a district level administrative position currently holds the position of superintendent.

For individuals whose contact information was available, an analysis was conducted examining if TLA participants continue to be employed by their same school district at the time of their participation in the TLAs (See Table 19). In reviewing the data of former TLA participants, approximately 70% of TLA participants (70.7%, n=116) continue to be employed by their same district at the time of their participation in the TLAs; only 3.1% of participants (n=5) are currently employed by another school district.

Table 19: Current employer information of MSP TLA participants

Employer	n	%
Same district	116	70.7
Different district	5	3.1
Unable to locate	43	26.2
	n=164	100.0

4.3.1 SURVEY DATA

Additional information was collected in the survey describing the current role and position of the individuals in the sample (n=19). In the survey, participants were asked to describe any changes that may have occurred to their role or position since their participation in the TLAs (See Table 20). In this sample, the largest number of respondents (26.3%, n=5) specifically indicated no change to their role or position. Another group (21.1%, n=4) indicated they either changed teaching assignments, returned to teaching mathematics, returned to school to obtain a doctorate degree or became the data analysis supervisor. The participant who indicated she had returned to graduate school also indicated she currently teaches mathematics methods courses for future elementary teachers and Algebra and Geometry pre-service teachers. One respondent (5.2%) indicated multiple responses for this question.

Table 20: Since your participation as a Teacher Leader in the MSP TLAs, have you. . .

Description	n	%
Changed teaching assignments to a non-mathematics position in the same district	2	10.5
Changed teaching assignments to an elementary position	0	0.0
Assumed a non-mathematics teaching position in a different district	1	5.2
Assumed an administrative position in the same district	0	0.0
Assumed an administrative position in a different district	2	10.5
Assumed an administrative position not in a school district	0	0.0
Assumed a position not responsible for providing or supervising mathematics instruction	0	0.0
No Change	5	26.3
Other	4	21.1

(*Six respondents skipped this question.)

4.3.1.1 MSP TLA Experience and Present Day

Section I of the survey asked respondents to indicate how well the MSP TLAs prepared them to deal with several factors relevant in mathematics instruction today. They were provided the following options: *did not prepare, had no effect, slightly prepared* and *significantly prepared* and were asked to indicate how well their experiences in the TLAs prepared them to address the *Common Core/PA Core Standards, Standards for Mathematical Practice, the role of* *mathematical tasks, the role of student dialogue, structuring the classroom learning environment for mathematics learning* and *the role of reflection in teaching*.

In terms of the Common Core/PA Core Standards, a number of participants (57.9%, n=11) indicated their experience in the TLAs somewhat prepared them (either slightly or significantly) to address the new content-based standards (See Table 21). Moreover, a greater number of respondents (78.9%, n=15) indicated their experiences in the TLAs prepared them in some way to address the Standards for Mathematical Practice (process-based standards). Furthermore, 78.9% of respondents (n=15) also indicated the TLAs prepared them to address structuring the classroom environment for mathematical learning. A substantial number of respondents (89.5%, n=17) indicated the TLAs prepared them in some way for both the roles of mathematical tasks and also the role of reflection in teaching. The large majority of participants (94.7%, n=18) indicated their experiences in the TLAs prepared them to address the role of student dialogue in mathematics to some degree.

Table 21: Level of preparation TLAs provided to deal with:

Factors	Did not prepare		Had no effect		Slightly prepared		Significantly prepared	
	n	%	n	%	n	%	n	%
Common Core/PA Core	3	15.8	5	26.3	10	52.6	1	5.3
Standards for Mathematical Practice	2	10.5	2	10.5	12	63.2	3	15.8
Role of mathematical tasks with students	0	0.0	2	10.5	7	36.8	10	52.6
Role of student dialogue in mathematics	0	0.0	1	5.3	12	63.2	6	31.2
Structuring the classroom environment for the learning of mathematics	0	0.0	4	21.1	9	47.4	6	31.2
Role of reflection in teaching	0	0.0	2	10.5	13	68.4	4	21.1

[2]Shading denotes the mode for a particular category.

Moreover, these data were disaggregated further and cross-tabulated to represent the variables of years of teaching experience and teacher leadership experience. These were reported in contingency tables (See Table 22 & Table 23). The variable of years of teaching experience was divided into two categories: more than 10 years of experience (63.2%, n=12) and 10 or less years of experience (36.8%, n= 7). The variable of teacher leadership experience was defined to be either those who had some type of teacher leadership experience (63.2%, n=12) and those who had no teacher leadership experience (36.8%, n=7). For Table 22 and Table 23, the categories of preparation, *did not prepare, had no effect, slightly prepared* and *significantly prepared* were collapsed into three reporting categories: *did not prepare, had no effect* and *prepared.*

Table 22: Cross-tabulated by teaching experience and level of preparation TLAs provided to deal with:

Factors	Did not prepare				Had no effect				Prepared			
Years of Teaching Experience	> 10 years		≤ 10 years		> 10 years		≤ 10 years		> 10 years		≤ 10 years	
	n	%	n	%	n	%	n	%	n	%	n	%
Common Core/PA Core	1	8.3	2	28.6	3	25.0	2	28.6	8	66.7	3	42.9
Standards for Mathematical Practice	1	8.3	1	14.3	2	16.7	0	0.0	9	75.0	6	85.7
Role of mathematical tasks with students	0	0.0	0	0.0	2	16.7	0	0.0	10	83.3	7	100.0
Role of student dialogue in mathematics	0	0.0	0	0.0	1	8.3	0	0.0	11	91.7	7	100.0
Structuring the classroom environment for the learning of mathematics	0	0.0	0	0.0	4	33.3	0	0.0	8	66.7	7	100.0
Role of reflection in teaching	0	0.0	0	0.0	2	16.7	0	0.0	10	83.3	7	100.0

[3]Shading denotes the mode for a particular category.

Overall, in terms of years of experience, these data suggest the largest number of respondents for both groups of teachers (those with more than 10 years of experience and those with 10 years of experience or less) reported their experiences in the TLAs prepared them (either slightly or significantly) for responding to each of the following: *Common Core/PA Core, Standards for Mathematical Practice, the role of mathematical tasks, the role of student dialogue, structuring the classroom environment for mathematical learning* and *the role of reflection in teaching*. The mode for every factor for both groups of teachers occurred in the prepared category; moreover, it is noteworthy to indicate for teachers with ten years of experience or less, all respondents (100.0%, n=7) indicated the TLAs prepared them to deal with *the role of mathematical tasks with students, role of student dialogue in mathematics, structuring the classroom environment for the learning of mathematics* and *the role of reflection in teaching*. It is important to consider all teachers with ten years of experience or less indicated their experience in the TLAs prepared them to deal with *the role of mathematical tasks with students, role of student dialogue in mathematics, structuring the classroom environment for the learning of mathematics* and *the role of reflection in teaching* in their classrooms. This is an important consideration since each of the identified factors is relevant in mathematics instruction today.

Table 23: Cross-tabulated by leadership experience and level of preparation TLAs provided to deal with

Factors	Did not prepare				Had no effect				Prepared			
Teacher Leadership Experience	Yes		No		Yes		No		Yes		No	
	n	%	n	%	n	%	n	%	n	%	n	%
Common Core/PA Core	2	16.7	1	14.3	3	25.0	2	28.6	7	58.3	4	57.1
Standards for Mathematical Practice	0	0.0	2	28.6	1	8.3	1	14.3	11	91.7	4	57.1
Role of mathematical tasks with students	0	0.0	0	0.0	2	16.7	0	0.0	10	83.3	7	100.0
Role of student dialogue in mathematics	0	0.0	0	0.0	1	8.3	0	0.0	11	91.7	7	100.0
Structuring the classroom environment for the learning of mathematics	0	0.0	0	0.0	2	16.7	2	28.6	10	83.3	5	71.4
Role of reflection in teaching	0	0.0	0	0.0	2	16.7	0	0.0	10	83.3	7	100.0

[4]Shading denotes the mode for a particular category.

Similar to the previous data reported, the contingency table for teacher leadership experience also suggests overall the greatest number of respondents for both groups of teachers (those with teacher leadership experience and those without teacher leadership experiences) report their experiences in the TLAs prepared them (either slightly or significantly) for the *Common Core/PA Core, Standards for Mathematical Practice, role of mathematical tasks, role of student dialogue, structuring the classroom environment for mathematical learning* and *the role of reflection in teaching.* The mode for each factor for both groups of teachers occurred in the prepared category. For the category of those without teacher leadership experience, all of the respondents (100.0%, n=7) reported their experience in the TLAs prepared them to deal with *the role of mathematical tasks, the role of student dialogue in mathematics* and *the role of reflection in teaching*. The results and the relatively small sample size affirm that these findings should not be generalized across the population. However, these data suggest that TLA participants in this study, regardless of their teacher leadership experience, self-reported their experiences in the TLAs helped to prepare them for each of the indicated factors.

4.3.1.2 Alternative Career Pathways

As previously discussed, the survey was designed using multiple pathways. For those who provided mathematics instruction during the 2012-2013 school year, they were directed to questions asking them about instructional and assessment practices they used with their target class. For those who did not provide mathematics instruction during the 2012-2013 school year, they were directed to respond to questions asking them about the influence of the TLAs on their current work. The majority of respondents (78.9%, n=15) were responsible for providing mathematics instruction during the 2012-2013 school year with 21.1% (n=4) of respondents indicating they were not responsible for providing any mathematics instruction during this time (See Table 24).

Table 24: Providing mathematics instruction during the 2012-2013 school year

Description	n	%
Responsible for providing mathematics instruction	15	78.9
Not responsible for providing mathematics instruction	4	21.1
	n=19	100.0

For individuals who were not responsible for providing any mathematics instruction during the 2012-2013 school year, the survey asked participants to explain any factors leading to this. Several factors were indicated. These include teaching both mathematics and science classes depending on the year, teaching mathematics methods courses to pre-service teachers, and budget cuts resulting in the elimination of the Title 1 program in the district which eliminated her teaching position. One respondent indicated at the time of her participation in the

TLAs, she served as the district's Curriculum Director and enrolled in the TLAs to deepen her knowledge of the recommended practices as related to mathematics instruction. Because the four individuals were no longer directly responsible for providing mathematics instruction, they were asked to indicate if their experiences in TLAs had any effect on their career pathways (See Table 25). Of this small group of respondents, 75.0% of the participants (n=3) reported the experience had no effect on their current career pathway; however, one respondent (25.0%) indicated her experience slightly influenced her career pathway.

Table 25: Influence of experience in MSP TLAs' effect on career pathway

Response	n	%
Had no effect	3	75.0
Slightly influenced	1	25.0
Moderately influenced	0	0.0
Significantly influenced	0	0.0
	n=4	100.0

4.3.2 SEMI-STRUCTURED INTERVIEW DATA

For this study, four teachers participated in semi-structured interviews. Each teacher currently has some responsibility for providing mathematics instruction. For the purposes of reporting the semi-structured interview data, the teachers will be identified as Teacher A, Teacher B, Teacher C and Teacher D. Teachers A, B, and D currently teach mathematics at the high school level; whereas, Teacher C teaches mathematics at the junior high level. Teacher C also instructs Physics courses. In addition to providing some demographic information, teachers were also asked to identify why they elected to participate in the TLAs.

Teacher A

Teacher A has served as a high school mathematics teacher for the past 24 years. Most of her 24 years of teaching experience have occurred in her current district. She currently teaches Honors Algebra 2 and Geometry at the high school. When asked why she participated in the TLAs, she explained the curriculum director, at the time, approached her about this opportunity and asked if she would be willing to participate. She explained initially five teachers or so from her district participated; however, a few of these teachers dropped out along the way. Teacher A participated in the entire TLA experience.

Teacher B

With 17 total years of teaching experience, the first 12 years of Teacher B's career were spent teaching middle school mathematics, although she currently teaches PreCalculus, Algebra 2 and a Keystone Recovery course at the high school. This is her fifth year teaching mathematics at the high school. When asked why Teacher B chose to participate in the TLAs, she explained it was because most of the teachers who agreed to participate were high school teachers, and at the time they were also looking for a middle school teacher.

Teacher C

Teacher C teaches both mathematics and Physics courses. She is currently responsible for three periods of seventh grade mathematics and one period of a seventh grade PreAlgebra; however, she also has an advanced Physics class and a regular Physics class. When she started at her current school in 2003, she taught eighth grade mathematics which was divided between PreAlgebra and Algebra courses. Two years later, she switched to teaching Physics and Physical Science. The past few years she has alternated between teaching Physics and teaching mathematics; however, more of her courses are typically in science. When asked why Teacher C chose to participate in the TLAs, she said it was because she had been approached by her superintendent. She explained:

> the superintendent at the time, he encouraged me to attend them. Basically what happened was he wanted someone from math discipline I guess to go, and I was teaching eighth grade math. But, whenever I started to teach physics, I said, hey can I switch to the science one rather than the math one [TLA] because that's feeling more relevant.

Teacher D

Teacher D is also a high school mathematics teacher; she has eight years of experience all of which have occurred at her current school. Teacher D currently teaches AP Calculus, Algebra 2 and an Algebra 1 lab; moreover, she currently serves as the high school mathematics department chair. She has served in this position for the past three years. When asked to elaborate upon her responsibilities as the high school department chair, Teacher A stated she is responsible for disseminating information from administration to the other department members and is responsible for the department's budget. Furthermore, she also explained that she helps facilitate conversation around curriculum. When asked to explain this, she stated:

> a couple of years ago, we started to re-write our curriculum, and so we had summer curriculum writing hours. We started as a district math group. There were teachers from all grade levels focusing on math curriculum. We, the assistant superintendent, the principal leader, which was the high school principal, and each principal took a subject area. Our high school principal took math, and we made a presentation on what is
> Common Core and what are the practice standards. That was sort of my part of the presentation-what does it mean to incorporate practice standards into your curriculum, and we kicked off our curriculum writing by agreeing on a template and starting all of

that. From now on, every year we have math task force meeting once a year where we revisit our curriculum, and we will talk about issues and try to continue to improve it.

When asked why Teacher D chose to participate in the TLAs, she explained she was approached about it after she completed her first year of teaching. The department chair at the time had the responsibility of attending the TLAs and was supposed to bring that information back to the department. However, at the time, the department did not have a lot of time to share this information, and this particular teacher was near retirement. Teacher D explained:

> she came to me at the end of my first year and asked me if I would pick it up, do a summer institute and then follow-up throughout that next year. To be honest, I think she picked me because I was the new teacher, and no one else wanted to do it. And she was my mentor. So I kind of just had to say yes.

In regard to the TLA, Teacher D expressed her appreciation of the experience. She indicated that after the TLA summer institute she entered into her second year of teaching so much more confident with what she was doing in her classroom.

4.4 RESEARCH QUESTION #2

4.4.1 SURVEY DATA

The second research question the findings of this study addressed is ***"What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?"*** For the course of the 2012-2013 school year, teachers were asked to identify the frequency of specific instructional and assessment practices typically used in their classroom relative to their target class. During the course of a school year, they were asked to categorize how often specific instructional practices were used in terms of the following: *none*, *little (less than 10% of the time), some (11-25% of the time), moderate (26-50% of the time), considerable (51-75% of the time)* and *almost all (> 75% of the time)* (See Table 26). Of the 15 participants responsible for providing mathematics instruction during the 2012-2013 school year, 14 respondents (93.3%) answered the questions regarding the use of instructional and assessment practices.

Table 26: Amount of the total mathematics instructional time students in the target class:

Instructional Practice	None		Little (< 10%)		Some (11-25%)		Moderate (26-50%)		Considerable (51-75%)		Almost All (> 75%)	
	n	%	n	%	n	%	n	%	n	%	n	%
Watch the teacher demonstrate how to do a procedure or solve a problem	0	0.0	1	7.1	3	21.4	8	57.1	1	7.1	1	7.1
Read about mathematics in books, magazines or articles (not including textbooks)	3	21.4	10	71.4	1	7.1	0	0.0	0	0.0	0	0.0
Take notes from lectures or textbook	0	0.0	2	14.3	5	35.7	5	35.7	2	14.3	0	0.0
*Complete computational exercises or procedures from a textbook or worksheet	0	0.0	0	0.0	3	21.4	6	42.8	4	28.6	0	0.0
Present or demonstrate solutions to a math problem to the whole class	0	0.0	2	14.3	4	28.6	5	35.7	3	21.4	0	0.0
Use manipulatives measurement instruments and data collection devices	2	14.3	5	35.7	4	28.6	3	21.4	0	0.0	0	0.0
Work on mathematical investigations or tasks	0	0.0	6	42.9	4	28.6	3	21.4	0	0.0	1	7.1
*Do mathematics activities with the class outside of the classroom	5	35.7	4	28.5	3	21.4	1	7.1	0	0.0	0	0.0
Use computers, calculators, or other technology to learn mathematics	0	0.0	1	7.1	4	28.6	4	28.6	1	7.1	4	28.6
Maintain and reflect a portfolio of their own work	5	35.7	1	7.1	4	28.6	2	14.3	0	0.0	2	14.3

(*Indicates this particular instructional practice was skipped by a respondent.)
[5]Shading denotes the mode for a particular category.

Prior to the execution of the study, three responses were categorized as traditional, teacher-centered mathematical instructional practices not necessarily emphasized within the TLA experience. The three traditional, teacher-centered instructional practices are *watching the teacher demonstrate how to do a problem, taking notes from a lecture or textbook* and *completing computational procedures from a workbook or textbook.* Each of the traditional teacher-centered instructional practices has been reported individually.

In terms of *watching the teacher demonstrate how to do a problem*, the largest number of participants (57.1%, n=8) indicated this occurred a moderate amount (26-50%) of the time in their target class. Overall, during the course of a school year, 71.4% of respondents (n=10) indicated this occurred for over 25% of the class time. For the instructional practice of *taking notes from a lecture or textbook*, the greatest number of respondents (71.4%, n=10) indicated this constituted 11-50% of the targeted class's time during the course of the year. When asked about *completing computational procedures from a workbook or textbook*, the largest number of respondents (71.4%, n=10) indicated this occurred anywhere between 26-75% of the time during the course of the year. This suggests many of the sample participants still utilize a sizeable portion of instructional time *viewing teacher demonstrations of problems, taking notes* and *completing computational procedures*.

Prior to the execution of this study, the following instructional practices: *reading about mathematics in books, magazines or articles (not including textbooks), presenting or demonstrating solutions to a math problem to the whole class, using manipulatives, measurement instruments and data collection devices, working on mathematical investigations or tasks, doing mathematics activities with the class outside of the classroom, using computers, calculators, or other technology to learn mathematics and maintaining* and *reflecting upon a portfolio of their* *own work* were coded as standards-based instructional practices. For each of the instructional practices, teachers were asked to identify how much time students in the target class participated in the standards-based instructional practices during the course of a school year.

The most frequently cited instructional practice, categorized as standards-based in this study, was *using computers, calculators, or other technology to learn mathematics* with almost all of the respondents (92.9%, n=13) indicating this practice was used some of the time or more (≥ 10%). The second most frequently cited instructional strategy was *presenting or demonstrating solutions to a math problem to the whole class*. A substantial number of respondents (85.7%, n=12) indicated this was an instructional strategy used some or more (≥ 10%) of the time during the year. The third most frequently cited strategy was students *working on mathematical investigations or tasks*. Of the participants, 57.1% of the respondents (n=8) indicated their students participated in this type of instructional strategy some or more (≥ 10%) of the time during the year.

When identifying instructional practices in which students participated for the least amount of time, a substantial number of respondents identified *students reading mathematics in books, magazines or articles (not including textbooks)*. Of the survey participants, 92.9% (n=13) indicated this occurred for less than 10% of the time during the school year. Three respondents (21.4%) indicated this never occurred. The second least cited instructional practice was *doing mathematics activities with the class outside of the classroom*. Of the survey participants, 64.3% (n=9) indicated this is something students in their target class engaged with for little or none (< 10%) of the time. Of the remaining instructional strategies, 50.0% of the respondents (n=7) identified *using manipulatives, measurement instruments and data collection devices* with their students for little or less (< 10%) of the time. When asked about *maintaining and reflecting on a* *portfolio of their own work*, 42.9% of the respondents (n=6) indicated their students participated in this either little or none (< 10%) of the time during the year.

These data were also cross-tabulated to represent the variables of years of teaching experience and teacher leadership experience (See Table 27). When reporting the cross-tabulated data, the amount of total mathematics instructional time students in the target class participated in each of the instructional practices were collapsed into three categories*: little to none (0-10% of the time), some to moderate (11-50% of the time)* and *considerable to almost all (51-100% of the time).*

Table 27: Amount of the total mathematics instructional time students in the target class by years of teaching experience:

Instructional Practice	None to Little (0-10%)				Some to Moderate (11-50%)				Considerable to Almost All (51-100%)			
Years of Teaching Experience	> 10 years		≤ 10 years		> 10 years		≤ 10 years		> 10 years		≤ 10 years	
	n	%	n	%	n	%	n	%	n	%	n	%
Watch the teacher demonstrate how to do a procedure or solve a problem	0	0.0	1	20.0	7	77.8	4	80.0	2	22.2	0	0.0
Read about mathematics in books, magazines or articles (NOT INCLUDING TEXTBOOKS)	8	88.9	5	100.0	1	11.1	0	0.0	0	0.0	0	0.0
Take notes from lectures or textbook	1	11.1	1	20.0	6	66.7	4	80.0	2	22.2	0	0.0
*Complete computational exercises or procedures from a textbook or worksheet	0	0.0	0	0.0	4	44.4	5	100.0	4	44.4	0	0.0
Present or demonstrate solutions to a math problem to the whole class	2	22.2	0	0.0	5	55.5	4	80.0	2	22.2	1	20.0
Use manipulatives, measurement instruments and data collection devices	5	55.6	2	40.0	4	44.4	3	60.0	0	0.0	0	0.0
Work on mathematical investigations or tasks	6	66.7	0	0.0	3	33.3	4	80.0	0	0.0	1	20.0
*Do mathematics activities with the class outside of the classroom	5	55.6	4	80.0	3	33.3	1	20.0	0	0.0	0	0.0
Use computers, calculators, or other technology to learn mathematics	1	11.1	0	0.0	5	55.6	3	33.3	3	33.3	2	22.2
Maintain and reflect a portfolio of their own work	4	44.4	2	40.0	4	44.4	2	40.0	1	11.1	1	20.0

(*Indicates this particular instructional practice was skipped by a respondent.)
[6]Shading denotes the mode for a particular category.

When cross-tabulating by years of teaching experience, the data demonstrate similar trends of instructional practice use for teachers with over ten years of experience and for teachers with ten years of experience or less. When analyzing the traditional, teacher-centered instructional practice of *watching the teacher demonstrate how to do a procedure or solve a problem*, the mode for both teachers with over 10 years of experience and teachers with ten years of experience or less occurred within the some to moderate category (11-50%) of the time during the year. This same pattern occurred for the instructional practice of having *students take notes from lectures or textbook*; the mode for both groups of teachers for this instructional practice occurred within the some to moderate category (11-50%) of time. As far as *completing computational exercises or procedures from a textbook or worksheet*, the greatest number of respondents for teachers with over ten years of experience variable was split equally between the some to moderate (11-50%) category and the considerable to almost all category (51-100%). In contrast, all of the teachers with ten years of experience or less (100.0%, n=5) reported their students engaged in this practice for some to a moderate amount of time (11-50%) during the year.

The frequency of instructional practices reflecting standards-based practices were also reported for the two different groups. Regardless of years of teaching experience, both groups reported students *presented or demonstrated solutions to a math problem to the whole class* and students *used computers, calculators, or other technology* to learn mathematics for some to moderate amounts (11-50%) of time during the school year. When asked how often teachers engaged their students in *reading about mathematics in books, magazines or articles, not textbooks,* and how often students *did mathematics activities with the class outside of the* *classroom*, the mode for both groups of teachers occurred in the little to none range (0-10%) of time.

As far as students *using manipulatives, measurement instruments, and data collection devices*, 55.6% of teachers with over ten years of experience (n=5) reported this occurred for little to none (0-10%) of the time during the school year; however, 60.0% of teachers with ten years of experience or less (n=3) reported this occurred for some to moderate amount (11-50%) of the time during the year. When asked about the frequency students *worked on mathematical investigations or tasks*, 66.7% of teachers with over ten years of experience (n=6) reported this occurred little to none (0-10%) of the time; 80.0% of teachers with ten years of experience or less (n=4) reported students engaged in this practice for some to moderate amount (11-50%) of the time. In terms of having students *maintain and reflect a portfolio of their own work*, both groups of teachers reported similar patterns for this instructional practice. The greatest number of teachers with over ten years of experience (44.4%, n=4) reported using this practice for either little to none of the time or some to a moderate amount. This pattern was present for those teachers with ten years of experience or less. For this group, 40.0% of respondents (n=2) reported they engaged their students in this practice for either little to none of the time or some to a moderate amount of the time.

The data were also cross-tabulated based on the variable of teacher leadership experience (See Table 28). The cross-tabulation represented the instructional practices for teachers with teacher leadership experience and for teachers with no teacher leadership experience. Again, data reporting categories were collapsed into the following: *none to little (0-10% of the time), some to moderate (11-50% of the time),* and *considerable to almost all (51-100% of the time).*

Table 28: Amount of the total mathematics instructional time students in the target class by teacher leadership experience

Instructional Practice	None to Little (0-10%)				Some to Moderate (11-50%)				Considerable to Almost All (51-100%)			
Teacher Leadership Experience	Yes		No		Yes		No		Yes		No	
	n	%	n	%	n	%	n	%	n	%	n	%
Watch the teacher demonstrate how to do a procedure or solve a problem	0	0.0	1	20.0	8	100.0	3	50.0	0	0.0	2	33.3
Read about mathematics in books, magazines or articles (NOT INCLUDING TEXTBOOKS)	7	87.5	6	100.0	1	12.5	0	0.0	0	0.0	0	0.0
Take notes from lectures or textbook	0	0.0	2	33.3	7	87.5	3	50.0	1	12.5	1	16.7
*Complete computational exercises or procedures from a textbook or worksheet	0	0.0	0	0.0	5	62.5	4	66.7	2	25.0	2	33.3
Present or demonstrate solutions to a math problem to the whole class	1	12.5	1	16.7	5	62.5	4	66.7	2	25.0	1	16.7
Use manipulatives, measurement instruments, and data collection devices	3	37.5	4	66.7	5	62.5	2	33.3	0	0.0	0	0.0
Work on mathematical investigations or tasks	3	37.5	3	50.0	5	62.5	2	33.3	0	0.0	1	16.7
*Do mathematics activities with the class outside of the classroom	4	50.0	5	83.3	3	37.5	1	16.7	0	0.0	0	0.0
Use computers, calculators, or other technology to learn mathematics	0	0.0	1	16.7	5	62.5	3	50.0	3	37.5	2	33.3
Maintain and reflect a portfolio of their own work	2	25.0	4	66.7	5	62.5	1	16.7	1	12.5	1	16.7

(*Indicates this particular instructional practice was skipped by a respondent.)
[7]Shading denotes the mode for a particular category.

Again, the cross-tabulated data indicate similar trends for both groups of teachers. The modes for the traditional, teacher-centered instructional practices of *watching the teacher demonstrate how to do a procedure or solve a problem, taking notes from lectures or textbook* and *completing computational exercises or procedures from a textbook or worksheet* for both teachers with teacher leadership experience and teachers without teacher leadership experience occurred in the some to moderate range (11-50%) of time. Of those with teacher leadership experience 100.0% (n=8) of the respondents indicated *watching the teacher demonstrate how to do a problem* occurred for some to moderate (11-50%) of time. Of those without teacher leadership experience, 50.0% of the respondents (n=3) indicated students *watched the teacher demonstrate how to do a problem* for some to moderate (11-50%) of time; however, two respondents (33.3%) of this group indicated this occurred for a considerable to almost all (51-100%) of the time. As far as *taking notes from lectures or textbook*, the mode for both groups of respondents occurred in the some to moderate range (11-50%). For teachers with teacher leadership experience, 87.5% of respondents (n=7) indicated students participated in this for some to moderate (11-50%) of the time. For teachers without teacher leadership experience, 50.0% of respondents (n=3) indicated this occurred for some to moderate (11-50%) time as well. In terms of *completing computational exercises or procedures*, the mode for both groups of teachers occurred in the some to moderate range (11-50%) with 62.5% of teachers (n=5) with leadership experience reporting in this category and 66.7% of teachers (n=4) without leadership experience reporting in this category.

As far as standards-based instructional practices, the modes for *presenting or demonstrating solutions to a math problem to the whole class* and *using computers, calculators, or other technology to learn mathematics* both occurred in the some to moderate range (11-

50%). Furthermore, the modes for *reading about mathematics in books, magazines or articles* and *doing mathematics activities with the class outside* of the classroom both were reported in the little to none range (0-10%). In terms *of reading about mathematics in books, magazines or articles*, 87.5% of teachers with teacher leadership experience (n=7) and 100.0% of teachers without leadership experience (n=6) indicated this occurred in the little to none range (0-10%). When asked about *doing mathematics activities with the class outside of the classroom*, 50.0% of teachers with teacher leadership experience (n=4) and 83.3% of teachers without leadership experience (n=5) reported this occurred for little to none (0-10%) of the time.

When examining the cross-tabulated data for discrepancies, the mode for *using manipulatives, measurement instruments and data collection instruments* occurred in different categories for the two groups of teachers. Of those teachers with teacher leadership experience, 62.5% of respondents (n=5) reported students participated in this for some to a moderate (11-50%) of time. Of those teachers without teacher leadership experience, 66.7% of respondents (n=4) indicated students participated in this for none to a little (0-10%) amount of the time. A similar pattern existed for the instructional practice of *working on mathematical investigations or tasks*. For teachers with teacher leadership experience, 62.5% of respondents (n=5) stated students engaged with this for some to a moderate (11-50%) amount of time. The mode for teachers (50.0%, n=3) without teacher leadership experience occurred in the little to none (0-10%) range. The instructional practice of *maintaining and reflecting a portfolio of the students' own work* displayed a similar trend. The mode for teachers with teacher leadership experience occurred in the some to moderate range (11-50%) with 62.5% of these respondents (n=5) reporting this. When compared to teachers without teacher leadership experience, 66.7% of these respondents (n=4) reported their students engaged in this practice for none to little (0-10%) of the time.

Table 29 illustrates the amount of time teachers reported their students *solved word problems from a textbook or worksheet, solved non-routine mathematical problems, talked about their reasoning or thinking in solving a problem, applied mathematical concepts to "real-world" problems, made estimates, predictions, or hypotheses, analyzed data to make inferences or draw conclusions and completed* or *conducted proofs or demonstrations of their mathematical reasoning*. They were asked to report these in the context of how often their students engaged with such instructional practices as they worked individually on mathematics exercises, problems, investigations or tasks in their target class. They were also asked to categorize these by the amount of time students in their target class engaged in such activities as they worked individually throughout the course of the school year on mathematics exercises, problems, investigations or tasks. The following categories were provided: *none, little (less than 10% of the time), some (11-25% of the time), moderate (26-50% of the time), considerable (51-75% of the time)* and *almost all (>76% of the time).*

Table 29: Time students spent working INDIVIDUALLY on mathematics exercises, problems, investigations, or task for each of the following:

Instructional Practice	None		Little (< 10%)		Some (11-25%)		Moderate (26-50%)		Considerable (51-75%)		Almost All (> 76%)	
	n	%	n	%	n	%	n	%	n	%	n	%
Solve word problems from a textbook or worksheet	0	0.0	0	0.0	4	28.6	7	50.0	3	21.4	0	0.0
Solve non-routine mathematical problems (i.e., problems that require novel or non-formulaic thinking)	1	7.1	2	14.3	7	50.0	4	28.6	0	0.0	0	0.0
Talk about their reasoning or thinking in solving a problem, using several sentences orally or in writing	0	0.0	3	21.4	5	35.7	4	28.6	1	7.1	1	7.1
Apply mathematical concepts to "real-world" problems	0	0.0	1	7.1	5	35.7	2	14.3	6	42.9	0	0.0
Make estimates, predictions, or hypotheses	0	0.0	4	28.6	3	21.4	3	21.4	3	21.4	1	7.1
Analyze data to make inferences or draw conclusions	0	0.0	4	28.6	3	21.4	4	28.6	3	21.4	0	0.0
Complete or conduct proofs or demonstrations of their mathematical reasoning	2	14.3	5	35.7	3	21.4	2	14.3	2	14.3	0	0.0

[8]Shading denotes the mode for a particular category.

When students worked on mathematical exercises, problems, investigations or tasks individually, the instructional practice reported most frequently was *solving word problems from* *a textbook or worksheet*. All respondents (100.0%, n=14) indicated their students engaged in this individually at least some of the time or more (≥ 10%). A large number of respondents (71.4%, n=10) also indicated students spent a moderate amount of time or more (≥ 25%) of time engaged in this practice. Overall, the second most referenced instructional practice was *applying mathematical concepts to "real-world" problems*. All respondents (92.9%, n=13) except for one indicated this happened some of the time or more (≥ 10%) during the course of the year. One respondent indicated students encountered this instructional practice little of the time (< 10%) during the year. Furthermore, six respondents (42.9%) indicated students encountered this type of practice a considerable amount of time (50-75%); whereas, five respondents (35.7%) indicated this occurred for some of the time (11-25%).

When asked about *solving non-routine mathematical problems (i.e., problems that required novel or non-formulaic thinking)* and how often *students talked about their reasoning or thinking in solving problems by using several sentences orally on in writing*, 78.6% of respondents (n=11) indicated students spent some of the time (≥ 10%) or more engaged with these practices. However, the data for this sample suggest students *talked about their reasoning or thinking* more. Students participated in this practice more with 42.9% of the respondents (n=6) indicating this happened a moderate amount or more (≥ 25%); whereas, 28.6% of the respondents (n=4) indicated students *solved non-routine mathematical problems* a moderate amount or more (≥ 25%).

For the instructional practices of *making estimates, predictions, or hypotheses* and *analyzing data to make inferences or draw conclusions*, the patterns were similar. Ten respondents (71.4%) indicated as students worked individually on mathematical problems, exercises, investigations or tasks, they did so for at least some of the time (≥ 10%) during the course of the year. In addition, within both of these categories, four respondents (28.6%) indicated students did this for little of the time (< 10%).

As students worked individually on mathematical problems, exercises, investigation or tasks, the least frequently identified practice was *students completing or conducting proofs or demonstrations of their mathematical reasoning*. Of the survey participants, 50.0% of the respondents (n=7) indicated this occurred for some of the time or beyond (≥ 10%); whereas, 50.0% of respondents (n=7) indicated students engaged in this for little or none (< 10%) of the time.

Participants were also asked to report the amount of time students in the target class engaged in instructional practices as they worked in pairs or small groups on mathematical exercises, problems, investigations or tasks (See Table 30). The instructional practices identified for this section were the same as the instructional practices respondents were asked to describe as students worked individually on mathematical problems, exercises, investigation or tasks. However, included in this section was the identification of the amount of time students *worked on a problem that took at least 45 minutes to solve*. This was included in this section of working collaboratively with other students since a problem like this would be typically given in a collaborative setting.

Respondents were asked to identify the time their students spent as they worked in pairs or small groups on math exercises, investigations or tasks for specific instructional practices. The instructional practice of *solving word problems from a textbook or worksheet* was identified as being used by the greatest number of respondents (28.6%, n=4) for a considerable amount (51-75%) of time. Every respondent indicated this occurred for at least some of the time with the majority of respondents (71.4%, n=10) reported this comprised at least 11 percent of the class time.

As students worked with other students on mathematical exercises, problems, investigations or tasks, an equal number of respondents reported two instructional practices occurred either some of the time (11-25%) or a moderate amount of time (26-50%). Such instructional practices included students engaged in *solving non-routine mathematical problems* and students engaged in *talking about their reasoning and thinking in solving mathematical problems*. In fact, five respondents (35.7%) reported students engaged in *solving non-routine mathematical problems* for some of the class time (11-25%) and five respondents (35.7%) reported this occurred for a moderate amount (26-50%) of the class time. Moreover, in time spent engaging students in *talking about their reasoning and thinking of solving mathematical problems*, two respondents (14.3%) indicated this occurred for a considerable amount of time (≥ 50%) or more. Thirteen respondents (92.9%) indicated students *applied mathematical concepts to "real world" problems* for anywhere from some (11-25%) of the school year to a considerable (51-75%) amount of the school year. As far as the instructional practice of *making estimates, predictions or hypotheses*, 11 respondents (78.6%) stated this occurred at least some of the time or more (≥ 10%). One respondent (7.1%) indicated this instructional practice occurred for almost all of the school year.

For the instructional practice of *analyzing data to make inferences or draw conclusions*, all the respondents (100.0%, n=14) reported this occurred for a little to considerable amount of the school year. However, of these respondents, the largest number (35.7%, n=5) identified this instructional practice occurred for little (< 10%) of the time. In terms of *working on a problem requiring 45 minutes or more to solve*, eight respondents (57.1%) indicated this practice occurred for little or none of the time (< 10%). In fact, four respondents (28.6%) stated this occurred for little of the school year, and the other four respondents (28.6%) stated this had not occurred for any of the time during the school year; whereas, one respondent (7.1%) identified this practice occurred a considerable amount of time (51-75%) during the school year. The majority of respondents (71.4%, n=10) also indicated students engaged in the practice *of completing or conducting proofs or demonstrations of their mathematical reasoning* occurred for either little or none of the school year. For this group, eight respondents (57.1%) stated this occurred for little (< 10%) of the time during the school year; whereas, two respondents (14.3%) stated their students did not engage in this practice at all. Again, for this practice, one respondent (7.1%) indicated her students engaged in this type of practice for a considerable portion (51-75%) of the school year.

Table 30: Time spent that students worked IN PAIRS or SMALL GROUPS on math exercises, problems, investigations or tasks for each of the following:

Instructional Practice	None		Little (< 10%)		Some (11-25%)		Moderate (26-50%)		Considerable (51-75%)		Almost All (> 76%)	
	n	%	n	%	n	%	n	%	n	%	n	%
*Solve word problems from a textbook or worksheet	0	0.0	3	21.4	3	21.4	3	21.4	4	28.6	0	0.0
Solve non-routine mathematical problems (i.e., problems that require novel or non-formulaic thinking)	0	0.0	4	28.6	5	35.7	5	35.7	0	0.0	0	0.0
Talk about their reasoning or thinking in solving a problem, using several sentences orally or in writing	0	0.0	2	14.3	5	35.7	5	35.7	1	7.1	1	7.1
*Apply mathematical concepts to "real-world" problems	0	0.0	0	0.0	5	35.7	4	28.6	4	28.6	0	0.0
Make estimates, predictions, or hypotheses	0	0.0	3	21.4	5	35.7	3	21.4	2	14.3	1	7.1
Analyze data to make inferences or draw conclusions	0	0.0	5	35.7	3	21.4	2	14.3	4	28.6	0	0.0
Work on a problem that takes at least 45 minutes to solve	4	28.6	4	28.6	3	21.4	2	14.3	1	7.1	0	0.0
Complete or conduct proofs or demonstrations of their mathematical reasoning	2	14.3	8	57.1	1	7.1	2	14.3	1	7.1	0	0.0

(*Indicates this particular instructional practice was skipped by at least one respondent.)
[9]Shading denotes the mode for a particular category.

Respondents were also asked to describe how often students in the target class participated in specific activities as they worked with hands-on materials (See Table 31). They were provided the following options: *none, little (< 10% of the time), some (11-25% of the* *time), moderate (26-50% of the time), considerable (51-75% of the time),* or *almost all (>76% of the time).* The specific instructional practices included *working with manipulatives (i.e., counting blocks, geometric shapes, or algebraic tiles) to understand mathematical concepts, building models or charts* and *presenting information to others using manipulatives (i.e, chalkboard, whiteboard, posterboard, or projector).*

Table 31: Time students spent working on hands-on materials for each of the following:

Instructional Practice	None		Little (<10%)		Some (11-25%)		Moderate (26-50%)		Considerable (51-75%)		Almost All (> 76%)	
	n	%	n	%	n	%	n	%	n	%	n	%
Work with manipulatives (i.e., counting blocks, geometric shapes, or algebraic tiles) to understand mathematical concepts	3	21.4	3	21.4	5	35.7	3	21.4	0	0.0	0	0.0
*Build models or charts	3	21.4	2	14.3	5	35.7	2	14.3	1	7.1	0	0.0
Present information to others using manipulatives (i.e, chalkboard, whiteboard, posterboard, or projector)	1	7.1	2	14.3	5	35.7	4	28.6	2	14.3	0	0.0

(*Indicates this particular instructional practice was skipped by a respondent.)
[10]Shading denotes the mode for a particular category.

When describing their students' use of *working with manipulatives to understand mathematical concepts*, 57.1% of respondents (n=8) indicated it occurred for some (≥ 10%) of the time or more; however, six respondents (42.9%) indicated it occurred for little of (> 10%) of the time. Three respondents (21.4%) indicated this had not occurred at all during the course of the school year. When respondents were asked to describe the amount of time students in their target class spent *building models or charts,* eight respondents (57.1%) reported this occurred some of the time or more (≥ 10%); however, the largest number of respondents (35.7%, n=5) stated this occurred for 11-25% of the time during the year. In addition, five respondents

(35.7%) indicated this occurred for less than 10% of the class time, and three respondents (21.4%) stated this did not occur at all. The most frequently reported instructional practice students in the target class spent participating in as they worked with hands-on materials was *presenting information to others using manipulatives (i.e, chalkboard, whiteboard, posterboard, or projector)*. Of the survey participants, 11 of the respondents (78.6%) reported this occurred for some of the time or more (≥ 10%). Moreover, six respondents (42.9%) stated this occurred for more than 25% of the class time.

Participants were asked to describe the types of assessment practices used with their target class and were asked to describe the frequency of these practices during the course of the school year (See Table 32). They were asked to describe how often they used the following: *objective items (i.e., multiple choice, true/false), short answer questions such as performing a mathematical procedure, extended response items for which students must justify a solution, performance tasks or events (i.e., hands-on activities), individual or group presentation to teacher/class, portfolios, mathematics projects, other than those listed above* and *systematic observation of students.* Respondents were provided the following frequency options: *never, 1-4 times per year, 1-3 times per month, 1-3 times per week* and *4-5 times per week.*

Table 32: Frequency of use of techniques used when assessing students

Assessment Technique	Never		1-4 time per year		1-3 times per month		1-3 times per week		4-5 times per week	
	n	%	n	%	n	%	n	%	n	%
Objective items (i.e., multiple choice, true/false)	2	14.3	4	28.6	5	35.7	3	21.4	0	0.0
Short answer questions such as performing a mathematical procedure	0	0.0	0	0.0	1	7.1	11	78.6	2	14.3
Extended response items for which students must justify a solution	0	0.0	1	7.1	4	28.6	9	64.3	0	0.0
*Performance tasks or events (i.e., hands-on activities)	2	14.3	3	21.4	5	35.7	3	21.4	0	0.0
Individual or group presentation to teacher/class	2	14.3	5	35.7	4	28.6	3	21.4	0	0.0
*Portfolios	6	42.8	3	21.4	2	14.3	2	14.3	0	0.0
Mathematics projects, other than those listed above	3	21.4	9	64.3	2	14.3	0	0.0	0	0.0
Systematic observation of students	2	14.3	3	21.4	1	7.1	2	14.3	6	42.9

(*Indicates this particular instructional practice was skipped by a respondent.)
[11]Shading denotes the mode for a particular category.

In examining assessment practices most frequently used within the target class, the researcher chose to analyze these in terms of frequency of use. The most frequently cited practice was *systemic observation of students* with six respondents (42.9%) indicating this occurred four to five times per week. Both responses of *short answer questions such as performing a mathematical procedure* (78.6%, n=11) and *extended response items* (64.3%, n=9) for which students must justify a solution were reported as having occurred one to three times per week. The next most frequently assessment practice used was assessments containing *objective items (i.e., multiple choice, true/false)* and *performance tasks or events (i.e., hands-on activities).* Five respondents (35.7%) indicated objective items occurred one to three times per month; whereas, five respondents (35.7%) reported performance tasks occurred one to three times per month.

The greatest percentage of respondents indicated the assessment practices *individual or group presentations to teacher/class* (38.5%, n=5) and *mathematics projects* occurred (64.3%, n=9) one to four times per year. Of these, the largest number of respondents (64.3%, n=9) indicated they instituted mathematics projects. *Individual or group presentations* were cited as having occurred one to four times per year by five respondents (35.7%). The least identified used assessment practice was the use of *portfolios*. Six respondents (42.8%) indicated this never occurred in their classroom.

4.4.2 SEMI-STRUCTURED INTERVIEW DATA

The participants of the semi-structured interviews were asked several questions relating to current instruction and assessment practices being used in their classrooms today; they were also asked additional questions probing more deeply into the current use of these practices. The practices were coded into multiple categories falling under the general heading of classroom activity which encompassed instructional activities/strategies, assessment and student learning.

From here, multiple themes emerged including teacher-centered instruction, student-centered instruction. Additionally, the assessment practice of explaining solution methods emerged as a subtheme of student-centered instruction. For the purposes of this study, teacher-centered instruction aligns to traditional mathematics instruction; whereas, student-centered instruction aligns to standards-based mathematics instruction referenced throughout this study.

Teacher-centered instruction

When asked about instructional practices consistently used in their classrooms today, Teachers A, B, C and D all mentioned characteristics of traditional, teacher-centered classrooms. In fact, each teacher directly cited some characteristic of traditional mathematics instruction as previously identified in Chapter 1. For instance, Teacher A explicitly stated her classroom is more teacher-directed. She explained:

> I would say the majority is pretty traditional-teacher led sort of instruction. I don't say lecture because it's more. I'm trying to make more of a dialogue, but it is more teacher-directed-leading it towards a certain process. As students are in the class, they are taking notes and asking questions-sort or filling in steps as we go. I would say that was probably the majority of it. I do have some group work projects using technology.

Teacher B also named instructional practices typically associated with traditional mathematics instruction, although she indicated she is interested in doing more hands-on activities with her mathematics classes. Furthermore, she described her lessons as typically beginning with a warm up, a set of notes which students copy and then homework. As she assigns homework, she usually reviews at least two of the homework problems and then provides time for students to complete the homework assignment during class. She does this so students have opportunities to ask questions and clarify misunderstandings before they leave.

When asked about instructional practices used routinely in her class, Teacher C indicated lecture is a consistent instructional practice. She described:

> I am still too lecture-based. I want to be less lecture-based, but I don't know how to get away from that. I know there has to be a balance, but I am not sure what it is. If you give them an activity, say do blah, sometimes they just pull out.

Teacher C also discussed her use of open-ended tasks in the past. She expressed a little bit of frustration in the use of such tasks indicating it was difficult for her students to focus with these. In referring to open-ended tasks, Teacher C also mentioned her desire for control of her class in order to ensure students are engaging appropriately.

It is interesting to note both Teachers A and C explicitly mentioned the need to be in control of their classroom. In fact, Teacher A indicated she enjoys when her students engage in group projects; however, group projects lend themselves to "a lot of chatter that's not affiliated with math and I guess I try to keep it center on math discussions by me controlling it, it's probably control." Teacher C reiterated this same idea when she discussed the use of open-ended tasks in the classroom. In fact, Teacher C explained:

> you want to be in control of your class, you want your class to be doing what they are supposed to be doing and being on task. It is very hard to get them to focus on such an open ended task, and I am not sure if that's something that maybe after I taught math for a little while again I'd be better able to facilitate. But for right now, I am feeling like yeah, I can't keep them on task when the task is focused on what I am doing on the board.

Both Teachers A and C recognized the value of collaborative and open-ended tasks; however, both of them also indicated classroom management concerns relative to the use of these types of instructional strategies.

Teacher D's mention of teacher-centered, direct instruction occurred in a somewhat different context than Teachers A, B, and C. When asked to describe routine instructional practices, Teacher D explained she used a mixture of collaborative tasks. Her lessons begin with a task and a class discussion surrounding the context of the task. After students are provided individual think time, they work with a partner or small group to complete the task. Once they complete the task, students share their answers and discuss the different methods to solve the task. She explained she uses this particular structure because it allows for student misconceptions to arise at the beginning of the lesson; however, she also explained her need to incorporate some direct instruction. She indicated "I also do some direct instruction, because I feel like there is always a need to teach other methods or other specific skills that they are not just going to intuitively come up with on their own." Her lessons end with her providing students options again through another task. Although Teacher D mentioned her use of direct instruction, this occurred within more of a collaborative, open-ended context reflecting a student-centered/standards-based environment.

Student-centered instruction

When asked about instructional practices, each teacher also identified characteristics considered to be student-centered in nature which align to standards-based instruction as defined in Chapter 1. They discussed using authentic, problem-solving activities, student collaboration and the role of student discourse in their classes. Teachers also discussed how they were trying to step back and provide the students with more of an opportunity to contribute, to their own learning. Although the extent to which Teachers A, B, C and D incorporated such opportunities varied, each teacher reported various incidents and degrees of such practices occurring in their classrooms.

Teacher A explained she was more open to different kinds of solutions than she was prior to her experience in the TLAs. Prior to her TLA experience, she indicated she typically looked for a particular solution method from a student; however, now she is more likely to prompt students for various approaches to solve problems. She indicated:

> I have kids explain how they got it, and then I might say something like did anybody else do it a different way or an easier way. I just did it today. We're doing a unit on measurement in geometry, and you're looking at changing one of the dimensions and how it affects the surface area of a shape. One student said they actually figured out the surface area and then compared them and divided, just to see how it changed. Then other student said, 'why don't you just look at the formula and how the one variable changed'-more the Algebra way of looking at it rather than the plug and chug way of looking at it. Before I think I might have just taken the first student's answer and moved on.

Teacher A also explained her incorporation of collaborative computer projects she provides once every nine weeks. She enthusiastically discussed her inclusion of such technology projects. Specifically, she discussed a project that uses both Physics software and motion detectors. In the project, the students take a picture of something and analyze the graph from the mathematical perspective. She continued "I like those, those are really great. I wish that I can incorporate more of those, but I just haven't found anything for sort of a level that is geared for higher math."

When discussing instructional practices, Teacher B reported students are able to work collaboratively as they work on their homework problems. In fact, she indicated student desks in her classroom are typically arranged in groups of threes. She elaborated "I do like them in groups of threes because it does help and encourage them to talk to each other even if they just listen I'm hoping they will pick up from the other two." Furthermore, Teacher B also discussed the openness in her classroom which she indicated has occurred since her participation in the TLAs. Teacher B discussed:

> I probably evolved more into a more open classroom and I try to get them to answer the questions for themselves-to try to figure things out for themselves. I'm more patient rather than just doing the problems on the board.

Teacher B attributed her awareness of creating an open classroom valuing student contributions to her work in the TLAs. As she explained, "I think it [TLAs] does make you more aware as not to just lecture, to try and even to take the time to stop and let the students answer questions without just jumping right in." She also expressed her interest to do more hands-on activities with her higher level mathematics courses. She attributed this not happening due to it being difficult to establish time to find hands-on activities for the higher levels of mathematics and difficult finding time within the curriculum to integrate such activities

Teacher C discussed the regular use of foldables in her classroom. With foldables, students divide topics into little books, and students then fill the foldables with definitions and examples. She also explained how she has been trying to step back in the classroom and provide more ownership on the students and their learning. Teacher C commented:

> I am trying to step back and let the kids do things, which is very, very hard sometimes. In going over the homework, I have dry erase boards up there, which the kids will be assigned a problem. They write it down on the dry erase board and they need to present it. I try to get from them information on how did you get that answer and what was your thought process. Sometimes that works, sometimes that doesn't work so well.

When asked to elaborate upon why she felt this strategy did not work well sometimes, she stated some students are more articulate than others, and it can be difficult to hold students accountable while not embarrassing them in front of their peers. She also credited the inclusion of some of these strategies to her experience in the TLA. As she stated:

> before I participated in the Teacher Leadership Academy it was all lecture. There was no tear this paper apart and fold these things-none of that. I tried to do things with Algebra tiles and with integer chips. I haven't really done that successfully but I am trying. That was something that I necessarily wouldn't have done before the Teacher Leadership Academy. I try to get more feedback from the kids than what I did before. Part of the problem was I didn't teach very long before I did the Teacher Leadership Academy to really do a compare and contrast. That was my first year teaching here before I did the Teacher Leadership Academy.

When describing her instructional practices, Teacher D's description encapsulated characteristics of standards-based instruction as defined for this study. In standards-based mathematics instruction, teachers emphasize active learning with their students as they engage in interactive and problem-centered tasks (Alsup, 2005; Brown, 2003). Teacher D provides ample opportunities for students to collaborate. Student desks are arranged in groups of two, but students are also assigned to groups of four to provide students opportunities to collaborate in larger groups. The majority of Teacher D's lesson design revolves around tasks. Students are presented with a task and a discussion ensues surrounding the context of the task. Individual think time is provided and students work collaboratively to solve the task. Upon completing the task, students present and share their different solution methods. Teacher D does provide some direct instruction, but she ends the lesson by providing students with additional tasks. Again, these tasks have multiple solution methods. Collaboration and multiple solution pathways are emphasized. When Teacher D explained how the TLAs influenced her current mathematics instruction, she stated:

> It's affected how I approach it in instruction in every way. I really didn't know what was the best way to get students to think about that concept, so I sort of just gave examples-like I do, we do, you do sort of thing. I never knew what it was to give a task, have students work on that task and that it was okay to use multiple methods. I didn't have to just teach one method, and I still do that to this day. I always give students options and tell them that if it mathematically correct how can I argue with them. Maybe they had some better way of doing something than even I thought of and understanding that you are going to see math in different ways. You are going to learn it in different ways, and I am still learning it.

When reflecting back upon her experience in the TLAs, Teacher D expressed some concerns with creating a unit solely designed around tasks. In fact, she recalled a conversation she had with a MSP facilitator. As she explained:

> I remember a couple of years ago talking to one of the MSP facilitators. We were talking about moving towards me just not trying one task, but coming up with a series of tasks that would cover a unit, cover the major ideas in that unit and that would be my basis for my unit. Then other little things I would just put into place where they needed to go. So I tried to do that, but I dropped the ball on that as well, and I go back to, 'Okay, let me start with the task', then I need to do my direct instruction for a little while and then I'll end with the task as well. To be honest I've done it that way because of time. Because I noticed that when I do try to plan the series of tasks, I am so far behind where the other

> teachers are who teach Algebra 2. Or in Calculus, I already don't get through all of the AP content that they need for the test, and I get nervous and so I sort of go back.

Teacher D expressed her willingness to implement a unit designed upon tasks; however, her awareness of time and curriculum coverage deterred her from implementing this completely.

Teacher D also indicated her continued efforts to relinquish the focus on her role as the classroom teacher. She explained "every year I am able to let go a little bit more and step back and let students figure things out for themselves and struggle a little bit." She discussed the difficulty doing this at times due to her nature of wanting to help and assist students, although she recognized the value of allowing students to productively struggle with concepts.

Assessment practices-explaining solution methods

Each teacher was also asked to describe the assessment practices consistently used in their classroom. Two of the teachers (Teachers A and B) identified using more traditional types of summative assessments in their classes. Teachers C and D also spoke of summative assessments although they also had some different ways they approached their assessments. Across their assessments, the majority of the teachers discussed some integration of problems requiring students to explain their thinking and solution methods.

When asked to identify specific assessment strategies used consistently, Teacher A described "traditional paper and pencil tests." She also described the incorporation of a few open-ended questions in her tests as the inclusion of application problems. Through the inclusion of these open-ended questions, she is able to engage her students with higher order thinking.

Teacher B also described her use of routine assessment strategies. She explained she provides her students with multiple choice assessments, although there are some assessment questions where students have to explain how students would solve the problem, rather than actually solve the problem. Furthermore, she indicated students have difficulty doing this. She discussed:

> I will just give them a problem, and I will say to them please explain to me how you solve this rather than actually solving it. They do have a hard time with that. They describe what it is they're doing rather than explaining to me what it is they needed to do.

When asked to describe routine assessment practices, Teacher C discussed her use of standards-based grading which she had started implementing. At the end of the chapter, she assesses students on topics she feels are important from the chapter. She explained she has some uncertainty with standards-based grading as she is not sure if she is implementing it correctly. When asked more specifically about the type of problems her students encounter on assessments, she commented:

> it's still mostly rote. Here is the problem solve it. I'm working on the idea of doing things a little more open ended, and I try to include word problems but that kind of falls into separate category. And part of me looks at the tests sometimes and goes why am I bothering with this. Why can't I just say here are the questions, and this is the grade you get on the test? Because like I feel like I am making more work for myself, and I am not sure it's worth the effort.

Teacher D described her summative assessments as formative in nature as well; this is because her students are provided with opportunities to do an error analysis on their test. After their tests, students are provided with a form where they have to identify why they missed the problem. She explained she provides some choices (calculation error, reading error, not following directions, or lack of understanding as to how to approach the problem) to have students begin thinking as to why they made their specific error. Students then have to work through the problem again and provide an explanation as to how they were able to do this. For example, did the student use their notes or ask for help from another student?

When discussing assessment question types, Teacher D explained the level of questioning she typically elicits from her students. She discussed the inclusion of some questions requiring students to explain their thinking as to how they arrived at the solution. As she described her assessment questions:

> If we had to rank them on Bloom's taxonomy, I'd say they are mostly at the application level. We don't do very much true or false or multiple-choice or anything like that. It is mostly tasks that they have to complete and then they have to show their work. Not all the time, but occasionally they have to write explanations.

It is interesting to note three of the four teachers discussed their use of problems requiring students to explain how they arrived at the solution for the problem. Although these teachers approach this process differently, it arises as a common theme across their assessment practices. This type of assessment practice aligns with standards-based mathematics instruction since students are engaged in a constructivist approach focusing on the student's role in mathematical discourse (NCTM, 2001).

4.5 RESEARCH QUESTION #3

4.5.1 SURVEY DATA

The final research question the findings of this study addressed is ***"For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?*** In the survey, respondents were provided with several factors which may have either helped or hindered the use of standards-based instructional practices over time. Each of the factors was categorized into one of the following dimensions as defined by Anderson (1996): technical, political or cultural. Some of the factors fell into multiple dimensions. Factors falling into multiple categories have been identified as such.

Factors have been represented in tables depicting each of the dimensions: technical, political and cultural. The technical dimension is comprised of the following: *content knowledge, pedagogical content knowledge, current scheduling practices, role of standardized assessments, instructional time, planning time, the role of the textbook, providing different types of assessments, understanding of how students learn mathematics,* and *understanding of my role in how students learn mathematics*. For the political dimension, the following categories fall within this realm: *time*, *district leadership*, *school leadership*, *parent support* and *instructional resources*. The cultural dimension consists of the following: *department/grade level's expectations for teaching practices, student tracking, belief in the importance of drill and practice for students learning mathematics, value of collaboration with colleagues, covering the curriculum, beliefs about what a mathematics classroom looks like* and *beliefs about how* *students learn mathematics*. The two items regarding opportunities for participation in *on-going professional development both MSP* and *non-MSP* were identified as representing both the technical and political dimensions. Although the factors could represent multiple dimensions, they were categorized into the dimension they most represented prior to any data collection for the study occurred.

Respondents were asked to identify if specific items had *significantly hindered, slightly hindered, had no effect, slightly support* or *significantly supported* the implementation of the practices learned in the TLAs over time. Over time was defined to be when the respondent first participated in the TLAs until present day. For the purposes of data reporting, the categories have been collapsed into the following: *hindered, had no effect,* or *supported*. Of the participants responsible for providing mathematics instruction during the 2012-2013 school year, 100.0% (n=15) responded to the following questions asking about potential barriers and supports that may have helped or hindered the continued use of the instructional practices learned in the TLAs.

Table 33: Technical Dimension

Factor	Hindered		Had No Effect		Supported	
	n	%	n	%	n	%
My content knowledge	0	0.0	3	20.0	12	80.0
My pedagogical content knowledge (my understanding of best practices of instruction)	0	0.0	1	6.7	14	93.3
Current scheduling practices in my school (i.e., traditional, block, etc.)	2	13.3	8	53.3	5	33.3
Role of standardized assessments (PSSAs, Keystones, etc.)	2	13.3	5	33.3	8	53.3
Instructional time	3	20.0	7	46.7	5	33.3
Planning time	3	20.0	8	53.3	4	26.7
The role of the textbook as a primary source in my class	2	13.3	9	60.0	4	26.7
Providing different types of assessments (authentic, performance-based, etc.)	1	6.7	3	20.0	11	73.3

[12]Shading denotes the mode for a particular category.

For each of the items in the technical dimension, the following had the greatest number of respondents who reported as having no effect: *current scheduling practices, instructional time, planning time and the role of the textbook* (See Table 33). Of these, the largest number of respondents (60.0%, n=9) indicated *the role of the textbook as a primary source* in the class had no effect. As far as items that supported practices learned in the MSP TLA experiences, respondents identified *content knowledge, pedagogical content knowledge, role of standardized assessments* and *the provision of different types of assessments*. The largest number of respondents (93.3%, n=14) and (80.0%, n=12) identified their *pedagogica*l *content knowledge and content knowledge* supported the continuation of the practices they learned in the TLAs. This was followed by 73.3% of respondents (n=11) who reported *providing different types of assessments (authentic, performance-based, etc.)* supported the use of instructional practices experienced in the TLAs.

In general, for the technical dimension, the mode for each item fell in the category of either had no effect or supported. The largest number of respondents who reported items that hindered their continued use of practices learned in the TLAs did so for the categories of *time* (both *instructional and planning*). Overall, *time* (both *instructional and planning*) was cited by the greatest number of respondents (20.0%, n=3) as hindering the continuation of practices they learned in the TLAs; however, as previously stated, most respondents reported the items identified in the technical dimension either had no effect or supported the continuation of their use of the instructional practices learned in the TLAs.

Table 34: Political Dimension

Factor	Hindered		Had No Effect		Supported	
	n	%	n	%	n	%
Time provided for collaboration with colleagues	4	26.7	6	40.0	5	33.3
District leadership	1	6.7	11	73.3	3	20.0
School leadership	1	6.7	11	73.3	3	20.0
Parental support	1	6.7	12	80.0	2	13.3
Instructional resources of which I have access	0	0.0	5	33.3	10	66.7

[13]Shading denotes the mode for a particular category.

Of the items representing the political dimension, the largest number of respondents reported no effect for the following factors: *time for collaboration with colleagues, district leadership, school leadership and parental support* (See Table 34). *Instructional resources* was the only item identified with the largest number of respondents (66.7%, n=10) indicating it may have supported the continuation of the practices learned in the TLAs. Although the largest number of respondents indicated *time for collaboration* with colleagues had no effect, this particular item had five respondents (33.3%) who indicated it supported the continuation of these practice; whereas four respondents (26.7%) indicated that it hindered. Overall, in terms of the political dimension, the majority of respondents reported that each of the items had no effect, except the factor of *instructional resources* of which the mode occurred in the supported category.

Table 35: Cultural Dimension

Factor	Hindered		Had No Effect		Supported	
	n	%	n	%	n	%
My department/grade's expectation for teaching practices	1	6.7	9	60.0	5	33.3
The tracking of students into different math courses	1	6.7	7	46.7	7	46.7
My belief in the importance of drill and practice with students in mathematics	4	26.7	5	33.3	6	40.0
The value I place on collaboration with colleagues	1	6.7	4	26.7	10	66.7
The curriculum (I feel as if I have to cover all of it to prepare students for the next grade level of course.)	4	26.7	2	13.3	9	60.0
My beliefs about what a mathematics classroom should look like	0	0.0	4	26.7	11	73.3
My beliefs about how students learn mathematics	0	0.0	3	20.0	12	80.0

[14]Shading denotes the mode for a particular category.

Within the cultural dimension, most respondents indicated items in this category supported the continuation of the practices learned in the TLAs (See Table 35). The greatest number of respondents indicated the following items as supporting their work from the TLAs (ranked from greatest to least by number of respondents indicating it supported): *beliefs about how students learn mathematics, beliefs about what a mathematics classroom looks like, value of collaboration with colleagues, covering the curriculum and beliefs in the importance of drill and practice with students in mathematics*. Of these, 80.0% of the respondents (n=12) indicated their *beliefs about how students learn mathematics* supported the continuation of the practices they learned during their experience in the TLAs. Approximately 70% of the respondents (73.3%, n=11) indicated their beliefs about *what a mathematics classroom looks like* supported the continuation of these practices. Following this was 66.7% of respondents (n=10) indicating *the value placed on collaboration with colleagues* supported the continued implementation of the practices learned in the MSP TLAs. *Covering the curriculum* was cited by 60.0% (n=9) of respondents who indicated this supported their continuation of the TLA instructional practices. Forty percent (n=6) of respondents indicated their *belief in the importance of drill and practice in mathematics* supported their continuation of such practices.

The data in the frequency tables suggest the items identified in the cultural dimension may lend themselves to supporting the continued use of standards-based mathematical instructional practices over time. Because of the lack of statistical significance and relatively small sample, it is important not to generalize this finding to the population and to also consider the qualitative data collected in the semi-structured interview portion of this study.

Table 36: Technical and Political Dimensions

Factor	Hindered		Had No Effect		Supported	
	n	%	n	%	n	%
*Opportunities for on-going, focused professional development related to my work in the classroom	1	6.7	5	33.3	8	53.3
MSP professional development, OTHER than the TLAs, of which I have participated	2	13.3	5	33.3	8	53.3

(*Indicates this particular factor was skipped by a respondent.)
[15]Shading denotes the mode for a particular category.

Opportunities for on-going, focused professional development related to classroom work and other *MSP professional development opportunities (excluding the TLAs)* were identified as representing both the technical and political dimension (See Table 36). Certainly, the knowledge gleaned in such professional development addresses the technical dimension; however, opportunities to participate in such activities stem from the political dimension. In terms of technical and political dimension items, 53.3% of respondents (n=8) indicated both of these supported the continuation of the practices learned in the TLAs. For each of the items, five respondents indicated they had no effect. Even though the data from this sample suggest items from both the technical and political dimensions such as professional development may support the continuation of standards-based instructional mathematical practices over time, it is important to consider these findings in the context of the semi-structured interviews due to the constraints of the survey data.

4.5.2 SEMI-STRUCTURED INTERVIEW DATA

Each semi-structured interview participant was asked to provide information about any potential barriers or supports that may have helped or hindered their use of instructional practices over time. Arising from these questions, responses were categorized as potential barriers or supports. Within the barriers and supports, specific themes emerged. The themes were time, testing/accountability, preparation ethic, professional development, administrative support and the value of colleague collaboration. Each theme was also categorized into the following dimensions: technical, political and cultural (Anderson, 1996). The themes are reported as barriers or supports; the themes have also been aligned into one of the previously mentioned dimensions.

4.5.2.1 Barriers

From the semi-structured interviews, the following themes emerged as barriers hindering the use of instructional practices. The three themes that emerged were time, testing/accountability, and preparation (See Table 37). Each of the themes aligned to reflect the either the technical, political or cultural dimension.

Table 37: Themes Identified as Barriers

Dimension	Themes
Technical	Time
Political	Testing/Accountability
Cultural	Preparation Ethic

Technical-Time

Teachers A, B and D indicated a lack of time as contributing to not being able to implement certain instructional practices they were interested in pursuing. For instance, Teacher A explained how her district recently provided iPads to all students in the high school, and she expressed her desire to use the iPads as a tool in her classroom instruction. However, she also indicated there was not enough time provided to gain an adequate understanding as to how the iPad could support her curriculum. In addition to the lack of time, she stated she received little professional development related to this.

Teacher B pointed to lack of time as the reason she has been unable to include more hands-on activities for her upper level mathematics classes. When describing the use of hands-on activities, she explained:

> I'm assuming that they are out there. In Trigonometry we do a little bit more only because it's more geared to that. You can do that a little bit more because it's more geometry based. Precalculus is just the college algebra part of it. It's just really hard.

Teacher B also indicated she was referring to time in both finding hands-on activities and also the time needed to implement them. As she stated, “because you still have to get through your curriculum and they [hands-on activities] don’t always blend well.

Teacher D stated there were other instructional strategies she was interested in pursuing and implementing; however, due to a lack of time, she has been unable to do this. From her perspective, the lack of time was related to time to research the instructional strategies and a lack of opportunity to meet with colleagues to share the use of these strategies. As she discussed:

> if I am doing that I would want my colleagues to know that. This is what I am doing, and I would want to share that with them. We do not have the time to meet anymore and share. And also, I mean. . .I’d like some more time to research it and talk to others, who may be have done that, and I don’t have those opportunities really.

Several times throughout the interview, Teacher D expressed some frustration regarding her lack of time to meet and collaborate with colleagues.

Political-Testing/Accountability

Every teacher mentioned testing/accountability during the interviews. Teacher A mentioned her district has engaged in multiple attempts at addressing the content of the Pennsylvania System of School Assessment (PSSAs) and Keystones exams. In the past she explained she was involved in creating PSSA problems everyone across the school would use simultaneously. Moreover, she expressed some frustration having to realign curriculum to the Keystones and the Common Core numerous times as she was involved her district’s multiple attempts at realigning the Algebra 2 curriculum.

Teacher B discussed testing in the context of providing students with multiple assessments during the year. As she explained, the school administers the Classroom Diagnostic

Tool (CDT), common assessments and the Keystone exams. As a result, she felt administering multiple assessments detract from time teachers could be instructing. She also expressed her frustration when so much is now tied to these assessments. Teacher C's discussion of the standardized assessments also conveyed anxiety and frustration as she discussed her concern of covering enough of the curriculum to prepare students for the PSSA.

Teacher D expressed frustration regarding the Keystone exams. Prior to the Keystone exams, Algebra 2 teachers in her school were provided with a lab time where they were able to meet, discuss and plan for the instruction during the lab time; however, this also provided her and her colleagues with time to meet and plan for the Algebra 2 course. This time they once had is no longer available as it is now used for Keystone remediation.

Cultural-Preparation Ethic (Anderson, 1996)

In terms of the cultural dimension, preparation ethic appeared as a common theme amongst three of the teachers (Teachers B, C and D). Preparation ethic is "the idea that the accumulation of fairly discrete knowledge and skills, rather than critical thinking skills, will prepare students best for the next level of schooling" (Anderson, 1996, p. 59). For the purposes of this study, this idea of preparation has been enhanced to include the preparation of students for high stakes assessments such as the PSSAs or Keystone exams.

Teacher B expressed some frustration relating to how much she is able to do with her students during the time they are in her class. In her district, she feels much of the responsibility of students passing or failing a test rests on the teacher. As she explained, "they want you to do this and they want you to do that and things change and shift. I have the student for 45 minutes- there's only so much I can do with them."

When discussing how standardized testing has impacted her classroom instruction, Teacher C expressed some frustration related to the notion of preparation ethic as related to standardized testing. As she discussed:

> I feel like I need to cover a certain amount of topics, and I feel like I haven't covered enough yet this year. So the idea of taking more time to cover topics doesn't really-you know I have to cover all of this, and how/when do I find the time. I can barely cover it in a pour this down your throat format which I don't like. I feel like I am marching in place, and I am not sure what the reasonable expectations is.

Teacher D also discussed her responsibility to cover the curriculum in order to prepare students for upcoming assessments or the next course. In fact, Teacher D stated her inability to use units comprised of solely tasks was due to the amount of time it required to implement. When she had planned for her units to be a series of tasks, she expressed her concern because she becomes too far behind as compared to her fellow teachers. She also discussed her concerns of using a series of tasks that would not enable her to cover all the concepts needed for the AP test. During the interview, she indicated she already feels as if she is not able to cover all the content needed for this exam with the time and current structures she uses.

4.5.2.2 Supports

From the semi-structured interviews, the following themes emerged as supports assisting the use of instructional practices for this particular group of teachers. The three themes that emerged were professional development, administrative support and the value of colleague collaboration (See Table 38). Each of the themes aligned to either the technical, political or cultural dimensions.

Table 38: Themes Identified as Supports

Dimension	Themes
Technical	Professional Development
Political	Administrative Support
Cultural	Value of Colleague Collaboration

Technical-Professional Development

When asked about potential supports contributing to the teachers' repertoire of instructional strategies, each teacher referred to some form of professional development they had received. In fact, Teacher A credited the professional development she received for the Classrooms for the Future grant for the creation of the collaborative, technological projects she has instituted. As Teacher A discussed the current iPad imitative in her school, she reiterated the importance of district provided professional development. She stated "the professional development has to come from them unless I started looking for the outside sources which I haven't done that at all."

Teacher A also identified her experience in the TLAs as contributing to how she now interacts and responds to her students. As she explained, the biggest impact her experience provided is that it caused her to be open to different kinds of solutions to a problem. Prior to her experience in the TLAs, Teacher A typically tried to elicit a specific response from students; moreover, she said "I always sort of had this is the way we want to do it." Now, she listens to different possible answers and methods to affirm the growth of her students.

Teacher B also discussed professional development. She referenced both external and internal professional development she experienced. Locally, she explained each department is assigned one month and has to provide a type of strategy that can be used across content disciplines. Although she explained, some of these strategies are more easily implemented with her lower levels of mathematics classes. She does not feel she has been able to incorporate those strategies in her higher levels of mathematics. Teacher B also credited a Governor's Conference she attended as contributing to a change in her instructional practice. As she stated:

> one [Governor's Conference] was very much hands-on teaching math. Granted it was the basic algebra, probability and statistics and things like that, but it was still very interesting to see and trying to see if I could relate it to something else. That's where I got the idea of rather than describing they need to explain.

When asked about factors most influencing her current instructional strategies, Teacher C attributed external professional development as having the largest effect. She explained:

> probably what's most impacted is the outside professional development and collaborating with other people and talking about it. Okay, I am trying this, this is not working, it is working, have you tried anything, am I going crazy, and what has worked for you when you worked with this population.

Teacher C has received external professional development from other colleagues and online classes, although she acknowledged her recent efforts have been more directed to science professional development since that has been more of her focus.

When Teacher D discussed professional development, Teacher D discussed both internal professional development and external professional development. She explained how her district participated in the MSP Communities of Practice. The Communities of Practice started with MSP coordinators, administrators and department chairs walking through mathematics and science classrooms with a focus on student behaviors. From there, this group identified specific areas missing in the classrooms. The missing areas served as the goal for the Community of Practice. For the past two years, the goal for the Communities of Practice was to increase formative assessment opportunities. It is important to note Teacher D referenced the importance of the MSP professional development as supportive to her work; however, this was referenced in light of two other supporting factors (administrative support and colleague collaboration) that will be discussed in the next section.

Political-Administrative Support

In terms of supporting factors, administrative support was also mentioned by a couple of the teachers (Teachers B and D). When discussing her desire to include more hands-on activities, Teacher B explained her administration is supportive of this. As she stated, “they [administration] would probably like to see that, different types of hands-on activities. They’re very encouraging in that.” Although administration is supportive of this, she feels as if time is a barrier, and she stated the time is needed to research hands-on projects and to implement these in the curriculum.

As stated previously, Teacher D stressed the importance of administrative support in providing expectations for professional development for her and her colleagues. When asked about factors supporting her instructional practices, Teacher D explained:

> I mean I would say professional development through MSP, but then administrative support because there was always that expectation. I mean I feel like in some schools districts it was you do MSP because we need to do this, but in our school district it was you are going to do MSP. Then you need to take this stuff back and use it and try it. That was the directive from the administrators. They were really invested in it. So I’d say those two [professional development and administrative support] and collaboration

> because MSP just encourages you to collaborate. Like I said, for the past couple of years we have done Communities of Practice, so I learned a lot from my colleagues in doing it.

Teacher D was the only teacher who attributed colleague collaboration stemming from administrative support and administrative expectations.

Cultural-Value of Colleague Collaboration

All four teachers echoed the value of colleague collaboration in enhancing teaching practice. In fact, Teacher A credited the incorporation of her collaborative, technology projects to a fellow colleague. Additionally, Teacher A stated "I wouldn't have been able to incorporate the technology if there wasn't personal collaboration from a few fellow teachers." She explained how she relies on other teachers to test different instructional strategies she is interested in using first. She does this so they are then able to assist her in rolling out those strategies with minimal classroom disruption in her classes.

Teacher B also emphasized the importance of colleague collaboration. During her experience in the TLAs, she expressed much value in being able to network and talk with other colleagues who reside in schools similar to her. As she explained:

> when I actually got to talk to the teachers around me, I enjoyed that more–like the one guy who was from District A. Obviously he has nothing in common with me. He has no clue, none. No clue as to what it was like to teach at my school district. But, District B was there, District C was there, District D was there, and some of those school districts do have some of the same problems that my district has. And so it was very interesting to try and talk with them. When you were able to see the different methods and the different techniques they tried, because we're all kind of in the same boat.

She enthusiastically discussed how valuable it is for her to collaborate with colleagues from similar districts.

Again, Teacher C emphasized the importance of colleague collaboration. In fact, she credited many of the ideas she consistently uses in her classroom from other educators. During the interview, she indicated her educational philosophy is “steal, steal, steal.” She also felt as if she has been able to develop a better network for colleague collaboration with her fellow Physics teachers, although she is interested in developing a similar type of network for mathematics.

Teacher D spoke several times regarding the role and importance of colleague collaboration in her school. This was evident as she spoke about the Algebra 2 teachers meeting together and also the Communities of Practice. In the Communities of Practice, Teacher D and her fellow colleague (the science department chair) received MSP training, and it was expected both she and her colleague provided this training to the rest of their departments. This occurred in both mathematics and science. Although colleague collaboration was echoed throughout her interview, she indicated the structures for these powerful opportunities were not necessarily sustained due to issues such time, scheduling constraints and compensation issues.

5.0 DISCUSSION, CONCLUSIONS AND IMPLICATIONS

5.1 OVERVIEW OF THE STUDY

This study analyzed current career trajectories and professional experiences of teachers who participated in the MSP Teacher Leadership Academies in regard to their current role and district since the time of their participation; it also examined the types of self-reported instructional strategies used by teachers who participated in this long-term professional development experience. Furthermore, this study categorized the instructional strategies into two types: traditional and standards-based. Potential barriers and supports were identified that either supported or hindered the continued use of standards-based instructional strategies several years after the professional development experience occurred. Each barrier and support was categorized into one of the following dimensions: technical, political, or cultural (Anderson, 1996).

The study consisted of two data collection methods: a survey and semi-structured interviews. The survey was administered to all TLA participants for whom current contact information was available (73.7%). Respondents of the survey were also asked if they would participate in semi-structured interviews. This study included semi-structured interviews with four teachers from Southwestern Pennsylvania; the teachers are currently responsible for providing mathematics instruction to some degree. Both quantitative and qualitative methods were used in the data reporting and analysis.

5.2 DISCUSSION OF FINDINGS

The study addressed the following research questions:

1. What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?
2. What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?
3. For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?

5.2.1 RESEARCH QUESTION #1

The first research question addressed in this study was "***What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?***"

5.2.1.1 Current role/district

Although contact information was not available for some participants, current contact information was available for approximately 75% of TLA participants. Of this group, the data collected indicate 61.2% of TLA participants still continue to be responsible for providing some type of mathematics instruction. Moreover, these data also indicate that many of the individuals (70.7%) continue to be employed by the same district in which they were employed during their participation in the TLAs. This was reflected in the data gathered in collecting participants' contact information, and it was also reaffirmed with the data collected from the study's survey responses. There is some stability that exists for teachers in Southwestern Pennsylvania who participated in the TLAs since the program's culmination in 2008.

This contrasts sharply with what occurred with district and building level administrators during the timeframe of the TLA project. During the seven years of the MSP project, 75% of the K-12 superintendents and 70% of building principals in the program changed (Bunt, 2010). Moreover, the data indicating the large turnover of building and district level administrators are reflective of changes occurring from 2004 to 2008 only. If these data were extended to 2014, the change in administrators would be even larger. Consequently, this is an important finding of this particular study. Some stability exists with TLA participants; however, it occurs at the classroom level only (61.2%), and a number of TLA participants (70.7%) are still working in the same district they were employed during the time of their TLA experience.

One of the premises behind the creation of TLAs was the idea of fostering and sustaining teacher leaders in districts. Because of the level of stability occurring with classrooms teachers, the focus of the TLAs on fostering teacher leaders was extremely appropriate. Through the professional development experience of *Lenses on Learning* provided to administrators, the MSP project also attempted to address the importance of the role of administration in supporting the continued work of the TLAs. These findings reaffirm the MSP's creation of Leadership Action Planning Teams which consisted of a "vertical slice" of leaders at each level; the findings also reaffirm the importance of the Leadership Action Teams as a component of the MSP project (Bunt, 2010).

With NSF and USDOE allocating $21 million to support the work of the TLAs, establishing the focus of the TLAs on secondary mathematics teachers was an appropriate use of funding. In Southwestern Pennsylvania, there appears to be some level of stability for secondary mathematics teachers; consequently, directing reform efforts towards the teachers provided MSP districts with a stable foundation of knowledge related to standards-based mathematics instruction. Although MSP districts have and continue to have teachers who possess an understanding of standards-based mathematics (as provided by the TLAs), actually implementing and sustaining standards-based mathematical instructional practices in classrooms may require more than simply having received the professional development to do so.

A small number of TLA participants have exited the classroom completely to pursue administrative leadership positions, although this consists of a fairly small number of individuals (2.4%). Of those individuals who participated in this study and have assumed administrative positions, 75.0% of them indicated their experience in the TLAs had no impact on their current career pathway. One individual (25.0%) indicated her TLA experience impacted her career pathway in her leadership experiences.

5.2.1.2 Teacher Leadership Roles

Although the sample for this study is small, data collected reveal some information regarding leadership experiences for TLA participants. Leadership experiences consist of both administrator and formal teacher leadership roles such as department chair or curriculum leader. The data collected indicate a number of TLA participants (63.2%) have held teacher leadership positions for their schools; however, there are also TLA participants (36.8%) who have not held any formal teacher leadership positions. One of the premises behind the TLAs was strengthening teachers as leaders in the district. Even though leadership was a component of the TLAs, not all teachers have experienced formal leadership positions. Most likely, there are multiple reasons for this that may benefit from further study. Teacher leaders may not have felt their work in the TLAs was as highly valued as other work, or they may not have seen explicit connections between their TLA experience and the work of other competing building and district initiatives. Administrators may have not recognized the value of the experiences of their teacher leaders, and administrative turnover was so frequent it made it difficult to formally develop these teacher leaders. More research exploring the reasons why TLA participants were not provided formal teacher leadership roles would be beneficial. Even though not all TLA participants experienced formal teacher leadership positions, it cannot be assumed those teachers without leadership experiences did not resume some role of informal leadership role in their schools.

With such a high degree of administrative turn over, capitalizing on teacher leaders is an integral to ensuring the sustainability of standards-based practices. As teacher leaders work collectively, they may be able to influence administrators in terms of providing organizational structures that support the use of standards-based practices, such as the provision of time for collaboration both across and among schools. As a result, school districts need to create climates that seek and value teacher leadership input into the decision-making process.

5.2.1.3 Factors in mathematics instruction today

Another finding of this study concerns the level of preparation teachers felt their TLA experience prepared them to deal with factors relevant in mathematics instruction today such as the Common Core/PA Core, Standards for Mathematical Practice, role of mathematical tasks, role of student dialogue, structuring the classroom environment for mathematical learning and the role of reflection in teaching. Participants generally felt as if their TLA experience prepared them in some way (slightly or significantly) for each of the identified factors. Overall, participants identified their TLA experience most prepared them to deal with mathematical tasks (89.4%) and the use of student dialogue and discourse in the mathematics classroom (94.4%). This was also reiterated in the qualitative data.

However, the data also indicate teachers are not necessarily using tasks as a recurrent instructional practice. Some teachers still have conflicting beliefs as to how they can incorporate and manage the use of tasks within their curriculum and classrooms. Teachers were concerned with the amount of time such tasks take away from their coverage of curriculum. Gamoran et al. (2003) explained:

> since time is a teacher's most precious material resource, it is not surprising that teachers' views of administrative barriers to teaching for understanding focused on time—either time that they were required to devote to other tasks, or time that was denied to them when they wanted to focus on understanding student thinking. (p. 108)

Some teachers were also concerned with the classroom management of tasks. Consequently, it appears as if teachers may benefit from some additional professional development as to how to structure the use of tasks within their curriculum to effectively manage their classrooms. Furthermore, as Pennsylvania continues to implement educator evaluation systems emphasizing student test results, the concerns of having enough time in a curriculum to incorporate such tasks may increase.

The variables of teaching experience and teacher leadership experience were cross-tabulated by how the teachers' experiences in the TLAs prepared them to deal with: the Common Core/PA Core, Standards for Mathematical Practice, role of mathematical tasks, role of student dialogue, structuring the classroom environment for mathematical learning and the role of reflection in teaching. Teaching experience was defined by the following categories: teachers with more than ten years of experience (63.2%) and those with ten years of experience or less (36.8%). For teachers with ten years of experience or less, all respondents (100.0%) indicated their TLA experience prepared them to deal with the role of mathematical tasks, the role of student dialogue, structuring the classroom for mathematical learning and the role of reflection in teaching. This was not the case for teachers with over ten years of experience.

Teacher leadership experience was defined as teachers who have held formal teacher leadership positions (63.2%) as opposed to teachers who have not held teacher leader positions (36.8%). For the categories of the role of mathematical tasks, the role of student dialogue and the role of reflection, all respondents without teacher leadership experience (100.0%) indicated their experience in the TLAs prepared them to respond to each of these. This may have occurred because teachers with ten years of experience or less may also be teachers who have not yet encountered any formal leadership positions during their career, as they are relatively early in their teaching career. Overall, the findings indicate teachers who are earlier in their career view their TLA experiences as preparing them to deal with those factors relevant in mathematics instruction today. Consequently, it may be important to consider the timing of when professional development experiences reflecting the characteristics outlined in the literature review are provided. Teachers who are fairly new to the profession may be more willing to use the instructional practices promoted in such professional development experiences. If administrators want to change the instructional practices occurring in their schools, it may be important to consider offering professional development experiences earlier in a teacher's professional career.

Furthermore, it may be helpful for administrators to consider the frequency of which intensive professional development is provided to teachers. Although professional development is extremely important to developing and refining teacher practice, teachers can view themselves as continuously being professionally developed if they are consistently chosen to participate in intensive professional development. If teachers continuously feel professionally developed, then this may impact the utilization of the knowledge provided within that professional development experience.

5.2.2 RESEARCH QUESTION #2

Using both quantitative and qualitative data, this study addressed the research question of ***"What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?"*** The data shows that teachers continue to use a considerable amount of time engaging students in instructional practices considered to be traditional and teacher-centered in nature. In traditional mathematics instruction, there is a focus on computations and procedures, and "the major theme is for teachers to demonstrate, and students to practice, formal symbolic procedures" (Battista, 2001, p. 43). Both the quantitative and qualitative data of this study support this finding.

5.2.2.1 Traditional Mathematics Instruction

In the survey, the largest number of respondents self-reported their students engaged in watching their teacher demonstrate how to solve problems for a moderate amount of time during the school year (57.1%) with two additional respondents reporting this occurred for almost all or a considerable amount of time (13.3%). When teachers engage in this type of instructional practice, their behaviors align to traditional, teacher-centered mathematics instruction as it typically focuses on memorization, rote learning and application of the facts and procedures; as compared to standards-based instruction where conceptual understanding and student reasoning are emphasized (Goldsmith & Mark, 1999).

In addition, other instructional practices such as taking notes from lectures or textbooks and completing computational exercises from a textbook or worksheet were cited as occurring more frequently in target classes. Again, these types of instructional strategies align themselves to being more traditional and teacher-center as compared to standards-based. As opposed to traditional mathematics instruction, standards-based instruction employs a "corresponding pedagogical shift [that] has moved the focus from direct instruction, drill and practice toward more active student engagement with mathematical ideas through collaborative explorations, hands-on explorations, the use of multiple representations, and discussion and writing" (Goldsmith & Mark, 1999, p. 40). Taking notes and completing computational exercises do not reflect this pedagogical shift. Furthermore, as students worked either individually or in small groups on mathematical exercises, problems, investigations or tasks, one of the most frequently cited instructional practices was for students to solve word problems from either a worksheet or a textbook. A substantial number of respondents (66.7%) indicated this occurred a moderate amount or more. Typically, this type of instructional practice aligns with traditional mathematics instruction as word problems from textbooks do not necessarily evoke the types of problem-solving scenarios standards-based mathematics instruction advocates. Overall, the instructional strategies most frequently self-reported generally align to traditional mathematics instruction as teachers report using these practices more frequently in their classrooms.

Characteristics of traditional, teacher-centered instruction also emerged in each semi-structured interview. Of the four teachers interviewed, every teacher identified characteristics of traditional mathematics instruction. Teachers are continuing to report a substantial amount of instructional time utilizing instructional strategies aligned to traditional mathematics instruction. In fact, a few teachers explicitly stated their classes were teacher-directed and lecture-based which continues to remain a prevalent theme of mathematics instruction in the United States (Till Barlow, 2012). The quantitative and qualitative data of this study show that student discourse and dialogue, learning environment and analysis of teaching and learning which are emphasized in standards-based mathematics instruction are not necessarily the core dimensions currently driving the selection of instructional practices (NCTM, 2000). The findings indicate teachers continue to use traditional mathematical instructional methods more prevalently even though teachers received a substantial amount of professional development related to standards-based instruction in the TLAs. This indicates other factors may influence the large-scale implementation and institutionalization of standards-based instructional practices in classrooms.

Such factors may be related to current school and district structures provided to teachers as they work to implement standards-based practices. For example, participants of this study were asked to identify how often their students engaged in a problem taking 45 minutes or longer to solve; however, 86.6% of respondents indicated their target class meets for only 40-49 minutes daily. This type of organizational structure makes it difficult employ the standards-based practice of engaging students in a problem taking 45 minutes or longer to solve. If teachers are expected to incorporate standards-based instructional practices then district and school organizational structures may also need to change to accommodate this.

5.2.2.2 Standards-based mathematics instruction

Although traditional mathematics instructional practices continue to be prevalent, characteristics of standards-based mathematics instruction have surfaced as well. As defined in Chapter 1, standards-based mathematics instruction refers to classrooms where teachers emphasize active learning and engage their students in interactive and problem-centered tasks (Alsup, 2005). In standards-based classrooms, students are provided with opportunities to act on their environments in an effort to construct their own knowledge while also being provided authentic and collaborative problem solving opportunities (Brown, 2003).

Of the standards-based instructional practices, both the quantitative data and qualitative data demonstrate teachers are asking students to present or demonstrate solutions to mathematics problems. Through classroom and assessment opportunities, teachers are asking students to explain and justify their thinking. In standards-based classrooms, students engage in active problem solving, communication, making connections, creating multiple representations of their mathematics and justifying their mathematical ideas (NCTM, 2000). Providing opportunities for students to explain and justify their thinking attends to communication, creating multiple representations of mathematics and justifying mathematical ideas as called upon by NCTM (2000). In the survey, a number of teachers (53.3%) self-reported they asked students to present or demonstrate solutions to mathematical problems a moderate amount of time or more during the year. Teachers (60.0%) also indicated their students used computers, calculators or other technology to learn mathematics for a moderate amount of time or more. Elements of standards-based mathematics instruction have emerged in classrooms.

Teachers also reported some standards-based instructional practices being used as students work either individually or in small groups on mathematics exercises, problems, investigations or tasks. As students engage with these, teachers reported students are applying mathematical concepts to real-world problems for a considerable amount of time (42.9%), students are talking about their reasoning or thinking for some amount of time (35.7%) and solving non-routine mathematical problems for some of the time (50.0%). These types of instructional strategies align to standards-based mathematics as teachers are having students engage in interactive and problem-centered tasks (Alsup, 2005). Although such practices generally were not reported as frequently as the traditional mathematical instructional practices, the standards-based instructional practices were indicated as occurring for at least some of the time or more.

In the semi-structured interviews, teachers identified opportunities for students to share their thinking and provide multiple representations as to how they solve problems. The survey data indicated a number of teachers (73.3%) had students talk about their reasoning or thinking when solving problems some of the time or more. Teachers echoed this same statement during the semi-structured interviews. The provisions of well-designed problem-posing tasks for students also require skilled teachers who can manage the complexities of such contexts (Singer, Ellerton & Cai, 2013). Difficulties in executing problem-posing tasks were also mentioned throughout the interviews. Consequently, it may be beneficial for professional development to address classroom management and time concerns related to the implication of tasks.

Another interesting consideration related to the use of tasks in mathematics classrooms is that TLA participants felt prepared for the role of mathematical tasks within their classrooms. However, the survey data reporting how often students worked on mathematical investigations or tasks indicate something contradictory. In the survey, 66.7% of respondents indicated students worked on mathematical tasks for some of the class time or less. Although the participants reported feeling some level of preparedness for the role of mathematical tasks within their classroom, this has not necessarily translated into implementation. Through the TLAs, teachers received a strong knowledge base for using mathematical tasks; however, the lack of actual implementation of using such tasks may reflect the knowing-doing gap occurring in schools (Pfeffer & Sutton, 2000). As Pfeffer & Sutton (2000) described, the knowing-doing gap refers to how individuals turn knowledge about how enhancing organizational performance into actions consistent with such knowledge. The discrepancies reported within this study's data in may indicate the knowing-doing gap still continues to exist in schools today.

As gleaned through the semi-structured interview data, other potential reasons for the discrepancy in the data may be due to time, curriculum restraints and classroom management concerns. Although TLA participants feel prepared for the role of the mathematical tasks, there are other intervening factors preventing them from implementation. The Standards for Mathematical Practice advocate for the use of tasks that encourage students to engage with mathematics. Even though teachers may feel knowledgeable about tasks, they are not prepared to implement these into current classroom structures. This may be the result of previously mentioned barriers such as the knowing-doing gap, time and classroom management; however, there may be other reasons contributing to this as well.

Furthermore, although teachers identified their TLA experience prepared them to deal with the role of mathematical tasks in their classrooms, this was not reinforced as they reported the types of instructional strategies they use most frequently. This relate to the heightened emphasis of mathematics as discrete and disconnected skills and concepts emphasized under the old regime of PSSA testing. Prior to 2013-2014, the PSSA assessments did not reflect mathematical problems requiring students to possess a deep understanding of concepts and an understanding of the Standards for Mathematical Practices. As a result, teachers may have not valued the use of mathematical tasks as deeply since the PSSA assessment did not necessarily reflect this type of teaching.

The standards-based instructional practices reported the least frequently were: doing mathematics activities with students outside the classroom, reading about mathematics in books, magazines or articles and using manipulatives. In fact, respondents (35.7%) indicated students spent none of their class time doing mathematics activities outside of the classroom. When students worked either individually or in small groups, these were the standards-based instructional practices reported the least frequently: making estimates, predictions or hypotheses, completing or conducting proofs or demonstrations of mathematical reasoning, and students working on a problem that took at least 45 minutes to solve. Given the findings, it is not surprising these standards-based practices occurred the least frequently.

The instructional practices described reflect the essence of standards-based mathematical instructional practices. When traditional mathematical instructional practices still dominate, then instructional practices such as making estimates, predictions or hypotheses, completing or conducting proofs or demonstrations of mathematical thinking and working on problems requiring at least 45 minutes to solve are not occurring. Such practices require a more substantial shift in standards-based practices that may be more difficult to accomplish, as opposed other instructional practices. Where standards-based instructional practices are occurring in classrooms, there is more of an organizational structural change to mathematics; however, how children and teachers do and engage with mathematics may continue to be the same (Hiebert & Stigler, 2000). These specific standards-based practices require much more of a shift in teachers' belief systems regarding what mathematics instruction should look like. Although teachers may be subscribing to some standards-practices advocated in the TLAs, it is possible their overall belief systems still envision mathematics instruction as traditional and teacher-centered. Until such belief systems are transformed, teachers will continue to use traditional methods more frequently; moreover, when teachers use standards-based practices, they will continue to be those practices that reflect more of an organizational change in their instruction.

When teachers described their students' use of hands-on materials for working with manipulatives (35.7%), building models or charts (35.7%), and presenting information to others (35.7%), the largest number of respondents indicated it occurred for some of the time. In fact, the majority of respondents indicated each of these occurred for either some of the time or less. Again, using hands-on activities such as manipulatives, building models or charts and having students present information to others reflects the essence of standards-based mathematics instruction. Because traditional mathematical instructional methods dominate the type of instructional practices being reported in this sample, this is not surprising. Creating classrooms truly reflective of standards-based mathematics instruction requires more than organizational changes, and teachers may not be comfortable implementing such substantial changes due to their current belief systems of mathematics instruction.

5.2.2.3 Assessment

When teachers described their assessment practices, their responses reflected characteristics of both traditional mathematics instruction and standards-based mathematics instruction. Both the quantitative and qualitative data demonstrate teachers provide assessment opportunities for students to complete short answer questions and multiple choice questions; however, the data also indicate some of the teachers provide extended response questions where students must justify their solutions. The assessment practice self-reported most frequently was systematic observation of students. The largest number of respondents (42.9%) indicated this occurred almost daily. Short answer questions (78.6%) and extended response items (64.3%) were identified as occurring one to three times per week.

Closed-ended questions such as those captured through multiple choice and short answer prompts reflect traditional mathematics instruction. Extended response questions that provide students opportunities to both communicate and justify their methods of solving problems underscore the importance of student discourse which is reflected in standards-based mathematics instruction. Standards-based assessment practices are needed to prepare our students to think critically and engage in higher order thinking. Normore & Brooks (2012) explained:

> assessment of student achievement is changing, largely because today's students face a world that will demand new knowledge and abilities. In the global economy of the

twenty-first century, students will need to understand the basics, but also to think critically, to analyze, and to make inferences. (p. 53)

Open-ended, extended response items provide students with more opportunity to think critically and analyze mathematical problems. Students are being exposed to assessment questions reflective of traditional, mathematics instruction; however, they are also exposed to assessment questions reflecting elements of standards-based mathematics instruction. Although teachers may have experienced significant professional development related to standards-based instruction, this is not necessarily enough to ensure standards-based instruction is implemented fully in both instructional and assessment practices.

5.2.2.4 Cross-tabulated data trends

When examining the cross-tabulated data of instructional practices for trends, a few noteworthy patterns emerged. In reviewing the data in terms of years of teaching experience, teachers with ten or fewer years of experience were more likely to use mathematical investigations or tasks more frequently than teachers with more than ten years of experience. Furthermore, the use of manipulatives as a classroom instructional practice was more likely to occur more frequently in classrooms of teachers with ten or less years of experience. These patterns may occur because teachers with ten years of experience or less are more likely to try standards-based instructional practices, as they may still be tinkering with their instructional methods. When reviewing this same data through the lens of teacher leadership experience, teachers with teacher leadership experience were more likely to do mathematics activities with their students outside of the class; moreover, they were also more likely to incorporate the use of tasks and investigations into their classrooms more frequently than teachers without any formal teacher leadership experience. This may be related to confidence level of teachers with formal leadership experience. Because the teachers were leaders, they may be more confident overall, and this may translate to their instruction meaning they may be more likely to implement new classroom instructional strategies.

Overall, the results of this study are similar to findings published for a study conducted in China in 2012. In this study, the influence of curricular reform in primary mathematics was analyzed in Chinese classrooms. The results suggest reform-based curriculum increases the frequency of practices advocated by the reform without decreasing the use of conventional practices (Li, Ni, Li & Tsoi, 2012). As with the study conducted in China, the results of this study indicate teachers who received extensive professional development related to standards-based instruction have incorporated some standards-based instructional practices; however, the teachers continue to self-report traditional mathematical instructional practices more frequently.

This study indicates other factors may influence long-term use of instructional practices beyond teachers simply participating in an effective professional development experience. The TLAs were designed to be ongoing, sustained, grounded in the daily practice of teachers and focused upon both content knowledge and pedagogical content knowledge. The TLAs were designed to address content knowledge and pedagogical content knowledge in order for teachers to engage in reconstructing their beliefs of teaching and reconnecting those beliefs to their content knowledge and pedagogical content knowledge (Tananis, 2010). The importance of student mathematical discourse and mathematical tasks were avenues used to advocate for standards-based mathematics instruction. Although the findings show some standards-based instructional practices are being used, the findings also indicate traditional mathematical instructional practices are used more frequently. Consequently, other factors may impact the use of standards-based instructional strategies in mathematics classrooms. Administrators may have an important role in minimizing or maximizing potential factors that may affect the implementation and institutionalization of standards-based instruction in their buildings.

5.2.3 RESEARCH QUESTION #3

The final research question of this study was ***"For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?"*** Study participants were asked to identify potential barriers or supports which may have contributed to the use of their instructional practices since the time of their participation in the TLAs. Each barrier and support was categorized and reported into one of the following dimensions: technical, political or cultural (Anderson, 1996). Two factors were identified as representing multiple dimensions.

5.2.3.1 Technical Dimension

In the technical dimension, the following factors were identified most frequently as supporting: content knowledge (80.0%), pedagogical content knowledge (93.3%) and the provision of different types of assessments (73.3%). The remaining factors were identified most frequently as having no effect. Amongst the technical factors, content knowledge and pedagogical knowledge factors obtained the largest mode value. These two factors directly relate to the design of the TLAs. In fact, each TLA focused upon content and pedagogical content knowledge relative to specific grade levels (Williams et al., 2006).

The existing literature identifies professional development as most successful when it connects to content and student curriculum; moreover, teachers are provided with on-going time and focus to engage with such content and pedagogy (Walker, 2007). These ideas were the backbone of design behind the TLAs. Consequently, it is interesting to note content knowledge and pedagogical content knowledge were identified as potential supports in the technical dimension; moreover, opportunities for on-going, focused professional development related to classroom work were also identified as supports. This reaffirms the design of the TLAs. Similar beliefs were echoed in the qualitative data.

In the qualitative data, teachers discussed similar factors. When teachers described how their instructional practices have changed, content knowledge and pedagogical content were referenced. Some teachers explicitly described how their TLA experience affected their pedagogical content knowledge, and some referenced the contribution of their TLA experience to their content knowledge. The findings indicate enhancing both content knowledge and pedagogical content knowledge may have supported the use of standards-based mathematics instruction for participants in the TLAs. With the adoption of the Standards for Mathematical Practice, administrators may benefit from continuing to provide on-going, focused professional development experiences that contribute to the content and pedagogical content knowledge of their teachers.

5.2.3.2 Political Dimension

In analyzing the political dimension, the greatest number of respondents identified each factor as having no effect except for the category of instructional resources. Teachers indicated instructional resources (66.7%) supported the continuation of the standards-based practices in the

TLAs. This finding suggests teachers are able to access instructional resources assisting them in the implementation of standards-based mathematical instructional practices advocated in the TLAs. This also suggests teachers were able to find some alignment between instructional resources and the standards-based instruction advocated in the TLAs.

5.2.3.3 Cultural Dimension

When examining the cultural dimension, several factors emerged as being supportive to the continued use of the practices learned in the TLAs: beliefs in the importance of drill and practice (60.0%), value of colleague collaboration (66.7%), curriculum coverage (60.0%), beliefs about what a mathematics classroom should look like (73.3%) and beliefs about how students learn mathematics (80.0%). The majority of respondents indicated their department's/grade's expectations for teaching had no effect (60.0%), and student tracking was split between the categories of having no effect (46.7%) and supported (46.7%). Of these, beliefs as to how students learn mathematics, beliefs as to what a mathematics classroom should look like and the value of colleague collaboration obtained the greatest number of respondents self-reporting these factors. Again, each of these factors related to the design of the TLAs.

In fact, the TLAs employed research-based tools such as the Mathematical Tasks Framework to assist their work of reshaping teacher beliefs as to how students engage with mathematics. The Mathematical Tasks Framework consisted of representations as to how the types of mathematical problems students engage with may affect classroom instruction (Malik, 2004). This framework provided teachers with an understanding of how the selection of a task impacts how students become engaged with mathematics. Consequently, the framework addressed teacher beliefs related to how students learn mathematics and beliefs related to how a mathematics classroom should look. The findings reaffirm the design and construction of the TLAs and the use of tools such as the Mathematical Task Framework. Furthermore, the TLAs also addressed how students engage with mathematics. The use of the Mathematical Task Framework in conjunction with emphasis on multiple representations and multiple problem entry points attends to student engagement in mathematics. Factors attending to these beliefs from the cultural dimension support the continuation of the practices learned in the MSP TLAs over time.

Another important consideration is the value teachers place on colleague collaboration as related to their professional learning. The value of colleague collaboration was emphasized repeatedly throughout the qualitative data. Teachers passionately referenced how much they value their colleagues' insights. Opportunities for teacher collaboration were incorporated in the TLAs; moreover, the findings demonstrate teacher collaboration supports the continued use of the standards-based practices. This is an important finding for administrators to consider as the Standards for Mathematical Practice require students to engage in mathematics in ways that align to standards-based instruction. Administrators may assist this process by providing focused time and structures for teachers to collaborate upon such practices, both within and outside of their districts. Teachers find much value in collaborative opportunities.

Overall, the findings indicate factors stemming from the cultural dimension are most likely to support the continued use of instructional practices advocated in the TLAs. The cultural dimension speaks to the values, beliefs and school norms (Anderson, 1996). As discussed previously in the literature review, teacher beliefs and identities are extremely influential in affecting how teachers transform their classroom instruction. Beliefs emphasizing teacher-centered, traditional mathematics classrooms with a heavy focus on rote learning may be obstacles to the implementation of standards-based instructional strategies in mathematics classrooms (Johnson, 2006). A teacher's identity and beliefs serve as the backbone for how they will decide to implement new knowledge and instructional strategies (Battey & Franke, 2008). When employing standards-based instruction, teachers are asked to teach mathematics in a manner that may contradict their previously constructed identity and experiences of what it means to teach mathematics (Loucks-Horsley & Matsumoto, 1999). This speaks to the importance of factors in the cultural dimension in this study. As administrators work to support teachers in creating standards-based classrooms as needed by the Standards for Mathematical Practice, it is important for administrators to consider how they can deliberately attend to and encourage the cultural dimension factors. Teachers believe factors in the cultural dimension may support the implementation of their standards-based mathematics classrooms; consequently, administrators should consider how they can promote and sustain these beliefs as they relate to standards-based mathematics instruction. As Elmore (1995) indicated it is important to develop shared expectations and beliefs about what defines good instruction; organizational structures that accompany the shared expectations and beliefs should then be developed. This is an important consideration for administrators as they work to support standards-based mathematics instruction.

5.2.3.4 Multiple Dimensions

Opportunities for on-going, focused professional development situated in the teachers' work and MSP professional development other than the TLAs represented both the technical and political dimensions. Of the respondents 53.3% indicated these supported the continuation of the practices learned in the TLAs. This finding indicates teachers may see some alignment between recent opportunities for on-going, focused professional development and their experience in the TLAs.

5.2.3.5 Barriers

Although the modes of the survey data did not indicate factors as hindering the continued use of the practices learned in the TLAs, there were several factors self-reported more frequently as hindering the continued use of standards-based practices. When analyzing these factors, participants identified: beliefs in the importance of drill and practice in mathematics (26.7%), curriculum coverage (feeling as if the teacher has to cover everything to prepare students for the next grade or course) (26.7%) and time provided for colleague collaboration (26.7%) in the hindered category, even though the modes for each factor occurred in either the having no effect or supported category. Two of these factors, curriculum coverage and time, also emerged as themes in the semi-structured interviews.

Curriculum coverage, or as was previously discussed as preparation ethic was a reoccurring theme throughout the semi-structured interviews (Anderson, 1996). According to Anderson (1996), preparation ethic is “the idea that the accumulation of fairly discrete knowledge and skills, rather than critical thinking skills, will prepare students best for the next level of schooling” (p. 59). This theme emerged throughout the qualitative data; however, it emerged as preparing students for their next course and for their high stakes testing experience.

In the current state of testing, students may view mathematics as disconnected skills, facts and procedures rather than a connected set of ideas students can develop their own understandings (Ellis, 2008). In my professional work with teachers, it is clear that teachers feel a sense of urgency in ensuring they cover all material needed for the high stakes assessments, PSSAs, Keystones and AP exams, which may be why students view mathematical concepts as disconnected. It is interesting to note that within the quantitative data the majority of respondents indicated the role of standardized assessments either supported or had no effect on the implementation of instructional practices learned in the TLAs. This may be due to teachers' beliefs that standardized assessments assist in ensuring teachers instruct all the standards; however, this also could have occurred due to numerous other reasons. When examining this idea more deeply in the semi-structured interviews, concerns regarding high stakes assessment prevailed as a factor influencing the types of instructional strategies used.

In analyzing the quantitative data regarding curriculum coverage, the majority of respondents (60.0%) indicated it supported the continued use of the standards-based instructional practices learned in the TLAs. Some respondents (26.7%) also reported curriculum coverage hindered the use of standards-based instructional practices. The qualitative research instrument probed more deeply into this finding. The findings indicated teachers feel the need to cover the entire curriculum for the next grade or course hindered the use of standards-based instructional practices. During the TLAs, the major curricular ideas of mathematics were emphasized rather than teaching discrete concepts. If participants responded to this survey question through the lens of thinking about curriculum in terms of major concepts, as opposed to disconnected concepts, this could help to explain the discrepancy between the survey data and the semi-structured interview data.

5.2.3.6 Supports

The semi-structured interviews indicated time provided for colleague collaboration is important, although this is not necessarily reflected as predominately in the survey data. In the qualitative data, participants highly recognized the value of colleague collaboration; however, the structures and supports needed for colleague collaboration were not necessarily available within their schools. Teachers feel as if the notion of curriculum coverage (or preparation ethic) in addition to lack of time may be factors that undermine their willingness to implement standards-based instructional strategies. In a study Gamoran et al. (2003) also discovered:

> from the perspective of teachers, time is the most important material resource. Many teachers viewed the use of funds to provide time to work together on student thinking as the most important contribution to the design collaboratives. Over 60% of the teachers interviewed mentioned time as a resource, and for the vast majority, the most precious use of time was for planning and learning with other teachers. (p. 68)

Teachers recognize the importance and value of time; consequently, providing structured time for teachers to collaborate may encourage the continued use of standards-based instructional strategies.

The importance of administrative support became apparent in one of the semi-structured interviews. In the classroom where the teacher cited the use of standards-based instructional practices the most frequently, this teacher credited such expectations to the administrative directive provided to her and her colleagues. According to Gigante & Firestone (2006), in a study conducted on an MSP project in New Jersey, the authors explained:

> it is necessary for teacher leaders to be able to meet with teachers and offer assistance, to be able to build relationships, and to be able to take advantage of whatever skills they have. Administrators may be critical for helping teacher leaders access material resources. They can also free time by releasing teacher leaders from regular duties and by designing their assignments to minimize time demands (p. 304).

This teacher discussed the structures her administration created which allowed her to share the training she received through the MSP with her colleagues. Additional resources administrators are instrumental in providing to teachers to foster standards-based instruction are high expectations and shared visions for classroom instruction (Gigante & Firestone, 2006). Consequently, administrators would benefit from designing opportunities and structures for professional development to occur in the context of teachers' work and to maximize opportunities for colleague collaboration.

In closing, although teachers may receive research-based professional development experiences such as the TLAs, there are other factors that support or hinder the practices promoted in such professional development experiences. This study shows that factors pertaining to beliefs, values and norms (the cultural dimension) support the continued use of standards-based mathematics instruction. However, the idea of teachers having to cover a certain amount of curriculum to prepare students for high stakes testing or a future course hinders the use of the standards-based practices promoted in on-going, sustained professional development experiences. Furthermore, administrative expectations may also hinder or support the practices learned in the TLAs. When administrators have high expectations for staff to share knowledge gained from the professional development with colleagues, this supports the continued use of the standards-based practices learned in the TLAs. Providing focused time and structures for teachers to collaborate on such work may support the continuation of these standards-based practices in classrooms. This is important because administrators need to ensure their mathematics classrooms reflect the Standards for Mathematical Practice which advocate for standards-based mathematical instruction.

5.3 IMPLICATIONS AND CONCLUSIONS

5.3.1 IMPLICATIONS

Implications of this study exist for both educational practice and policy in Pennsylvania. As educators align and revise curriculum to the PA Core Standards, it is important the Standards for Mathematical Practice are an integral component of this work. Prior to the adoption of the standards, Pennsylvania had content standards only. The Standards for Mathematical Practice are process standards, and process standards reflect the tenets of standards-based instruction, as defined for this study. Ensuring the Standards for Mathematical Practice are a vital component of curriculum realignment efforts is needed for both administrators and teachers. It is a cultural shift for Pennsylvania teachers to attend to this process, and standards-based mathematics classrooms capture the process standards of the Standards for Mathematical Practice.

Although the practice standards are indicated in the PA Core, the supporting documents educators use to assist in preparation for high stakes testing such as the PSSAs and the Keystone exams do not specifically address the Standards for Mathematical Content. The tested eligible content documents are resources Pennsylvania educators may reference in developing an understanding of tested content; however, the Standards for Mathematical Practice are not communicated in these documents.

With the implementation of the redesigned PSSAs aligned to the PA Core, Pennsylvania has an opportunity to redesign assessments to provide students with opportunities to engage in the Standards for Mathematical Practice. Moreover, in the release of supporting materials to accompany the new PSSAs and Keystone exams, it is important to explicitly identify how the

Standards for Mathematical Practice connect to the assessments and the types of tasks provided on the assessments. It is important for teachers to be reminded the Standards for Mathematical Practice receive the same degree of attention as the content standards of the PA Core.

For practice, the results of this study identify potential supports educational systems can provide to assist the work of teachers as they implement the Standards for Mathematical Practice in their classrooms. With standards-based instruction, administrators should contemplate the supporting factors provided in this study and how these may influence their work with their mathematics departments. Even if the professional development provided to teachers aligns to what the literature identifies as effective for changing teacher practice, there are still other external factors which may advance or hinder the experiences received as related to the implementation of a standards-based classroom.

5.3.2 CONCLUSIONS

The findings of this study indicate some stability exists across Southwestern Pennsylvania for the classroom teachers who participated in the TLAs with regard to their current responsibility in providing mathematics instruction. This study also shows many of the participants continue to provide some type of instruction in the same districts where they were employed during their TLA experience. Due to the high frequency of administrators changing positions during the TLA experience, this is an important finding for consideration in the area of Southwestern Pennsylvania.

Teachers who participated in the TLAs continue to use instructional practices reflective of traditional mathematics instruction. In fact, traditional mathematics instructional practices were reported the most frequently in classrooms and for the greatest amounts of instructional time. Although traditional mathematical instructions continue to be reported, teachers also identified consistent use of some instructional practices reflecting standards-based instruction. Teachers are now using instructional practices that reflect both traditional mathematics instruction and standards-based mathematics instruction; however, traditional mathematical instructional practices are occurring more frequently.

As far as potential barriers and supports affecting standards-based instruction, barriers most often identified consisted of time and covering curriculum as required by high stakes standardized testing. The supports identified most frequently occurred in the cultural dimension and most often addressed beliefs concerning mathematics, content knowledge and pedagogical content knowledge. Although the sample for this study is small and the findings cannot be generalized across the population, the findings of this study still serve to provide some guidance for the implementation of standards-based instruction in classrooms today as called upon by the Standards for Mathematical Practice.

5.4 RECOMMENDATIONS FOR FURTHER RESEARCH

This study explored the long-term use of standards-based mathematical instructional practices after teachers received extensive professional development promoting this type of instruction. Additional studies exploring the long-term impact of the role of administrative support and administrative expectations would be valuable as schools transition to the Common Core/PA Core. Through the Standards for Mathematical Practice, the Common Core/PA Core promotes standards-based classroom experiences. Instruction requiring students to engage in process related standards, such as the Standards for Mathematical Practice, requires standards-based mathematics instruction (Till Barlow, 2012). Administrators may play an important role in developing, maintaining and supporting standards-based classroom environments.

Moreover, this is important because this study demonstrates there is some stability for TLA participants at the classroom level; however, there is a great deal of administrative turnover. Significant administrative turn over exists today, and a large number of administrative turnover existed during the TLA experience. If administrative expectations and support are important in promoting and maintaining standards-based instruction promoted in the TLAs, then there is value in conducting a more thorough analysis as to how administrative expectations support or diminish the effects of this type of professional development experience, especially in light of the high degree of administrative turnover existing in Southwestern Pennsylvania.

In light of this high administrative turnover rate, an additional recommendation for future study consists of examining how teacher leaders can be used to advanced standards-based mathematics instruction. It would be valuable to analyze current structures and roles of teacher leaders as to how they are used to create and support classrooms and schools promoting standards-based mathematics instruction. Although the MSP recognized the importance of the teacher leader as evidenced by the establishment of the TLAs, it would be beneficial to examine other structures (both formal and informal) teacher leaders could use to sustain the vision of standards-based mathematics classrooms.

Another potential study for exploration could relate to the new Educator Effectiveness System being instituted across Pennsylvania. The data gleaned from this study indicates teachers are concerned they are not covering enough material in order to prepare students for high stakes assessments such as the PSSAs and Keystone exams. As testing data is now linked to individual teacher performance through the Pennsylvania Value-Added Assessment System (PVAAS) teacher specific reporting and the School Performance Profile (SPP), will this create a greater sense of anxiety as teachers feel more of an urgency to cover all tested concepts? Furthermore, in this heightened system of accountability, it is important to consider how teachers will address the process standards the Standards of Mathematical Practice advocate. The study could analyze how emphasis on testing as required by the new Educator Effectiveness Evaluation System may result in mathematics educators focusing solely on content standards, rather than process standards, as measured on high stakes assessments.

A final area of study may expand upon the work of this study. This study examined the frequency of self-reported standards-based instructional practices used by teachers who participated in the TLAs. This study did not examine or compare the frequency of self-reported standards-based instructional practices used by mathematics teachers who did not participate in the TLAs as compared to those who did participate in the TLAs. Consequently, to gain a more comprehensive understanding of the overall impact of the TLAs on mathematical instructional practices, it may be beneficial to study both groups of teachers to identify similarities and differences occurring between the types of instructional strategies being used in their classrooms.

APPENDIX A

METHODOLOGY MATRIX

Question	Evidence	Data Source	Data Collection and Analysis	Data Reporting	Instrument Question Alignment
1. What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?	Identification of teachers and districts participating in TLAs from 2004 to 2008	Volume 14 of the Math & Science Collaborative *Journal*; this document can be located at: http://www.aiu3.net/Level3.aspx?id=9850	The *Journal* identifies teachers who participated in the secondary math TLAs. The researcher checked these names against school websites to determine if they were still teaching in that district and to determine their current role within the district. If they were not, the researcher conducted online searches to find their current contact information.	The results were reported in both narrative and tabular form.	Survey Questions: 1, 5, 10, 11, 13, 14, 15, 16 and 17 Semi-Structured Interviews: 1, 2, and 3

Question	Evidence	Data Source	Data Collection and Analysis	Data Reporting	Instrument Question Alignment
2. What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?	Administration of SEC modified for use in this study; Self-reported use of standards-based instructional strategies Semi-structured interview prompts	Used a non-probability sampling of teacher participants (secondary Math Teachers) in the TLAs Web-based survey (modified SEC) A subset sample of candidates participated in semi-structured interviews.	Data was reported using frequency distribution tables and measures of central tendency (mode) for the self-reported use of standards-based instructional practices. Semi-structured interviews occurred after the survey administration. The interviews were analyzed and coded by themes.	The results were reported using descriptive narratives and descriptive statistics (mode). Semi-structured interviews were reported using emerging themes.	Survey Questions: 31, 32, 33, 34 and 35 Semi-Structured Interviews: 4, 5, 6, 7, 8, and 9

Question	Evidence	Data Source	Data Collection and Analysis	Data Reporting	Instrument Question Alignment
3. For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?	Identification of Barriers/ Supports Anderson's (1996) Studies of Curricular Reform Conceptual framework using technical, political, and cultural dimensions	Web-based survey asked participants to identify factors that have served as barriers/ supports to the use of standards-based instruction-al practices Semi-structured interviews	Data was reported using frequency distribution tables; measures of central tendency (mode) were reported for the barriers and supports Semi-structured interviews occurred. These conversations were analyzed and coded by themes.	The results were reported using descriptive narratives and descriptive statistics (mode). Interviews were reported using emerging themes.	Survey Question: 36 Semi-Structured Interviews: Question 6, 7, 8, and 10

APPENDIX B

SURVEYS OF ENACTED CURRICULUM

Permission to use Surveys of Enacted Curriculum

Hi Jackie,

Thank you so much for contacting us about using the SEC for your dissertation work. We are happy to provide you permission to use the SEC for your study. We just ask that you properly site our work.

If you have any questions regarding the SEC, please let me know. I am happy to help!

Thanks,
Alissa Oleck
SEC Project Manager

Mathematical Instructional Practices in Southwestern PA

Survey Introduction

Thank you for participating in this research study. Participation is completely voluntary, and the survey should only take approximately 20-25 minutes to complete. Your responses will remain confidential; there is minimal risk to any individuals who participate.

There are two phases for this study. Phase 1 is the completion of this survey. As an incentive and thank you for taking the survey, you can enter a drawing for a gift card. Upon completion of the survey, you will be directed to a separate URL where can register your name, email and mailing address for entrance into the drawing.

Phase 2 of this research study consists of semi-structured interviews that will be conducted at a later date. Participation in the semi-structured interviews is also voluntary. Once the survey is complete, you will be asked if you are willing to participate in Phase 2 of this study. If yes, you will then be asked to provide your contact information. There will then be a possibility that the researcher will contact you after the survey closes to arrange for the semi-structured interview.

Please be assured all your survey responses will remain confidential. Any participants who complete the survey will be assigned random ID numbers in order to protect the confidentiality of responses. Any identifying information collected in this survey will not be used in any of the reporting and analysis of the data.

Thank you again for your willingness to participate in this research study. Please keep in mind that participation in both the survey and the semi-structured interview is voluntary. If you have any questions, please do not hesitate to contact me.

Jackie (Anderson) Removcik
jla62@pitt.edu
412-302-4356

Mathematical Instructional Practices in Southwestern PA

Section 1: Demographics

1. What is your role/position?

2. What is your gender?

- ◯ Female
- ◯ Male
- ◯ Other identified gender status

3. Please describe your ethnicity/race.

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Hispanic or Latino/a
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Other

4. Did you participate in the Math Science Partnership's Teacher Leadership Academies (TLAs)?

- ◯ Yes
- ◯ No

Mathematical Instructional Practices in Southwestern PA

Demographic Break

5. Not including the 2013-2014 school year, how many years have you: (Check ALL that apply)

	None	1 year or less	2-5 years	6-10 years	11-15 years	16-20 years	21 or more
Taught mathematics	◯	◯	◯	◯	◯	◯	◯
Taught mathematics at your current school	◯	◯	◯	◯	◯	◯	◯
Held a teacher leadership position (i.e. department chair, curriculum leader, etc.)	◯	◯	◯	◯	◯	◯	◯
Held a building level leadership position (assistant principal or principal)	◯	◯	◯	◯	◯	◯	◯
Held a district level leadership position (assistant superintendent, director, supervisor, superintendent)	◯	◯	◯	◯	◯	◯	◯
Held a leadership position outside of a school district (i.e. curriculum director at an IU)	◯	◯	◯	◯	◯	◯	◯

Other (please specify)

6. What is the highest degree that you hold?

◯ Bachelors (BA or BS)

◯ Masters (MA, MS or MEd)

◯ Masters Equivalency

◯ Multiple Masters

◯ Doctorate (Ph.D. or Ed.D.)

7. What was your major field of study for your bachelor's degree? Check ALL that apply.

- ☐ Elementary Education
- ☐ Middle School Education
- ☐ Mathematics Education
- ☐ Mathematics
- ☐ Mathematics Education AND Mathematics
- ☐ Other Disciplines (includes other Education fields, Science, History, English, Foreign Languages, etc.)

8. If applicable, what was your major field of study for the highest degree you hold beyond a bachelor's degree? Check ALL that apply.

- ☐ Elementary Education
- ☐ Middle School Education
- ☐ Mathematics Education
- ☐ Mathematics
- ☐ Mathematics Education AND Mathematics
- ☐ Educational Leadership
- ☐ Other Disciplines (includes other Education fields, Science, History, English, Foreign Languages, etc.)

Other (please specify)

9. What type(s) of state certification do you currently have? Check ALL that apply.

- ☐ Emergency or provisional certification
- ☐ Elementary/Early childhood certification
- ☐ Middle School certification
- ☐ Secondary certification, in a field other than mathematics
- ☐ Secondary mathematics certification
- ☐ Special education certification
- ☐ Administrator certification (i.e., curriculum and supervision, principal, superintendent)
- ☐ National Board Certification

Other (please specify)

10. Since your participation as a Teacher Leader in the MSP's Teacher Leadership Academies, have you (check ALL that apply)

- ☐ changed teaching assignments to a non-mathematics position in the same district
- ☐ changed teaching assignments to an elementary teaching position (Grades K-5)
- ☐ assumed a mathematics teaching position in a different district
- ☐ assumed a non-mathematics teaching position in a different district
- ☐ assumed an elementary teaching position in a different district (Grades K-5)
- ☐ assumed an administrative position in the same district
- ☐ assumed an administrative position in a different district
- ☐ assumed an administrative position not in a school district
- ☐ assumed a position not responsible for providing or supervising mathematics instruction
- ☐ Other (please specify)

11. How well did the MSP Teacher Leadership Academies prepare you to deal with each of the following:

	Did not prepare	Had no effect	Slightly prepared	Significantly prepared
Common Core/PA Common Core	○	○	○	○
Standards for Mathematical Practice	○	○	○	○
Role of mathematical tasks with students	○	○	○	○
Role of student dialogue in mathematics	○	○	○	○
Structuring the classroom environment for the learning of mathematics	○	○	○	○
Role of reflection in teaching	○	○	○	○

Other (please specify)

12. Did you provide mathematics instruction to students during the 2012-2013 school year?

- ◯ Yes
- ◯ No

Administrator Questions

13. If you are no longer responsible for providing mathematics instruction, please explain the factors that led to this.

14. If you have assumed an administrative position, please explain the factors that led to this.

15. Did your experience as a Teacher Leader in the MSP's Teacher Leadership Academies have an effect on your career pathway?

- Had no effect
- Slightly influenced
- Moderately influenced
- Significantly influenced

If so, please describe how.

Mathematical Instructional Practices in Southwestern PA

16. How well did the MSP Teacher Leadership Academies prepare you to deal with each of the following:

	Did not prepare	Had no effect	Slightly prepared	Significantly prepared
Common Core/PA Common Core	◯	◯	◯	◯
Standards for Mathematical Practice	◯	◯	◯	◯
Role of mathematical tasks with students	◯	◯	◯	◯
Role of student dialogue in mathematics	◯	◯	◯	◯
Structuring the classroom environment for the learning of mathematics	◯	◯	◯	◯
Role of reflection in teaching	◯	◯	◯	◯

Other (please specify)

17. If you have assumed an administrative position, how has your participation in the MSP's Teacher Leadership Academies influenced your current work?

◯ Significantly hindered

◯ Slightly hindered

◯ Had no effect

◯ Slightly impacted

◯ Significantly impacted

If so, please describe how

Mathematical Instructional Practices in Southwestern PA

Target Class Instructions

Please select a SINGLE MATHEMATICS class that you instructed during the 2012-2013 (LAST) school year as the basis for your answers to most of the questions in this survey. This will be referred to as the TARGET class. If you are a teacher who taught only a single class, which included some time spent on mathematics activities, refer to those activities when you respond to the questions.

Instructions for Selecting your TARGET Class:

This target math class is defined to be a MATHEMATICS class you instructed during the 2012-2013 SCHOOL YEAR. If you taught more than one mathematics class during the 2012-2013 school year, please use the FIRST mathematics class you instructed each week as your targeted class. If you taught both required and elective classes, please choose a required class as your target class. This target class will be used as your point of reference for survey questions in Sections 2, 3, 4 & 5.

Section 2: School and Target Class Description

18. Which of the following categories best describes the way classes are organized at your school? (Check all that apply.)

- [ ] Departmentalized instruction
- [ ] Self-contained (i.e, teacher of multiple subjects)
- [ ] Team taught (i.e. two different teachers providing instruction)

Other (please specify)

Departmentalization Break

19. If your school is departmentalized, how many different mathematics classes do you currently teach?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7

Mathematical Instructional Practices in Southwestern PA

Non-departmentalization break

20. Which term best describes the target class you are referencing?

- ◯ Middle School Math
- ◯ PreAlgebra
- ◯ Algebra
- ◯ Integrated Math
- ◯ Geometry
- ◯ Trigonometry
- ◯ Advanced Math
- ◯ Calculus

Other (please specify)

21. Indicate the grade level of the MAJORITY of the students in the target class.

- ☐ 5th grade or below
- ☐ 6th
- ☐ 7th
- ☐ 8th
- ☐ 9th
- ☐ 10th
- ☐ 11th
- ☐ 12th

22. What percentage of the students in the target class were female? (Estimate to the nearest range.)

- ◯ 0-20%
- ◯ 21-40%
- ◯ 41-60%
- ◯ 61-80%
- ◯ 81-100%

23. What percentage of the students in the target class were members of a racial/ethnic group OTHER than white? (Estimate to the nearest range.)

- ◯ 0-20%
- ◯ 21-40%
- ◯ 41-60%
- ◯ 61-80%
- ◯ 81-100%

24. What percentage of students in the target class were Limited English Proficient? (Estimate to the nearest range.)

- ◯ 0-20%
- ◯ 21-40%
- ◯ 41-60%
- ◯ 61-80%
- ◯ 81-100%

25. What percentage of students in the target class were students with disabilities? (Estimate to the nearest range.)

- ◯ 0-20%
- ◯ 21-40%
- ◯ 41-60%
- ◯ 61-80%
- ◯ 81-100%

26. During a typical week, approximately how many hours did the target class spend in mathematics class?

- ◯ 0-1
- ◯ 2-3
- ◯ 4-5
- ◯ 6-7
- ◯ 8-9

27. What was the average length of each class period for the target class?

- ○ Less than 30 minutes
- ○ 30-39 minutes
- ○ 40-49 minutes
- ○ 50-59 minutes
- ○ 60-69 minutes
- ○ Over 70 minutes

28. How many total weeks did the target class meet this past school year (2012-2013)?

- ○ 1-12
- ○ 13-24
- ○ Over 25 weeks

29. Estimate the achievement levels of the MAJORITY of the students in the target class relative to incoming/previous PSSA or Keystone scores?

- ○ Advanced
- ○ Proficient
- ○ Basic
- ○ Below Basic
- ○ Mixed Achievement Levels

30. Of the following factors, please identify those considered to be most important when scheduling students into the target class?

- ☐ Ability or prior achievement
- ☐ Limited English proficiency
- ☐ Teacher recommendation
- ☐ Parent request
- ☐ Student decision
- ☐ No one factor is more important than the other

Other (please specify)

Section 3: Instructional Practices in Mathematics

Activities for student engagement in mathematics are listed below. Consider each activity with regard to your target class. What percentage of the total yearly instruction time might a typical student in the target class spend engaging in each activity? Make your best estimate. Your answers may exceed 100% as some of these activities may be combined in some lessons.

31. Over the course of the year, how much of the total mathematics instructional time did students in the target class: (mark on in each row)

	None	Little (<10% of time)	Some (11-25%)	Moderate (26-50%)	Considerable (51-75%)	Almost all (>76%)
Watch the teacher demonstrate how to do a procedure or solve a problem	○	○	○	○	○	○
Read about mathematics in books, magazines or articles (NOT INCLUDING TEXTBOOKS)	○	○	○	○	○	○
Take notes from lectures or textbook	○	○	○	○	○	○
Complete computational exercises or procedures from a textbook or worksheet	○	○	○	○	○	○
Present or demonstrate solutions to a math problem to the whole class	○	○	○	○	○	○
Use manipulatives (i.e., geometric shapes or algebraic tiles), measurement instruments (i.e., rulers or protractors), and data collection devices (i.e., surveys or probes)	○	○	○	○	○	○
Work on mathematical investigations or tasks	○	○	○	○	○	○
Do mathematics activities with the class outside of the classroom	○	○	○	○	○	○
Use computers, calculators, or other technology to learn mathematics	○	○	○	○	○	○
Maintain and reflect a portfolio of their own work	○	○	○	○	○	○

32. When students in the target class worked INDIVIDUALLY on mathematics exercises, problems, investigations, or tasks, how much time did they: (mark one in each row)

	None	Little (<10% of time)	Some (11-25%)	Moderate (26-50%)	Considerable (51-75%)	Almost all (>76%)
Solve word problems from a textbook or worksheet	○	○	○	○	○	○
Solve non-routine mathematical problems (i.e., problems that require novel or non-formulaic thinking)	○	○	○	○	○	○
Talk about their reasoning or thinking in solving a problem, using several sentences orally or in writing	○	○	○	○	○	○
Apply mathematical concepts to "real-world" problems	○	○	○	○	○	○
Make estimates, predictions, or hypotheses	○	○	○	○	○	○
Analyze data to make inferences or draw conclusions	○	○	○	○	○	○
Complete or conduct proofs or demonstrations of their mathematical reasoning	○	○	○	○	○	○

33. When students in the target class worked IN PAIRS or SMALL GROUPS on math exercises, problems, investigations or tasks, how much time did they: (mark one in each row)

	None	Little (<10% of time)	Some (11-25%)	Moderate (26-50%)	Considerable (51-75%)	Almost all (>76%)
Solve word problems from a textbook or worksheet	○	○	○	○	○	○
Solve non-routine mathematical problems (i.e., problems that require novel or non-formulaic thinking)	○	○	○	○	○	○
Talk about their reasoning or thinking in solving a problem, using several sentences orally or in writing	○	○	○	○	○	○
Apply mathematical concepts to "real-world" problems	○	○	○	○	○	○
Make estimates, predictions, or hypotheses	○	○	○	○	○	○
Analyze data to make inferences or draw conclusions	○	○	○	○	○	○
Work on a problem that takes at least 45 minutes to solve	○	○	○	○	○	○
Complete or conduct proofs or demonstrations of their mathematical reasoning	○	○	○	○	○	○

34. When students in the target class worked on HANDS-ON MATERIALS, how much time of that did they: (mark one in each row)

	None	Little (<10% of time)	Some (11-25%)	Moderate (26-50%)	Considerable (51-75%)	Almost all (>76%)
Work with manipulatives (i.e., counting blocks, geometric shapes, or algebraic tiles) to understand mathematical concepts	○	○	○	○	○	○
Build models or charts	○	○	○	○	○	○
Present information to others using manipulatives (i.e, chalkboard, whiteboard, posterboard, or projector)	○	○	○	○	○	○

Section 4: Assessment Practices

35. How often did you use each of the following techniques when ASSESSING students in the target math class:

	Never	1-4 times per YEAR	1-3 times per MONTH	1-3 times per WEEK	4-5 times per WEEK
Objective items (i.e., multiple choice, true/false)	◯	◯	◯	◯	◯
Short answer questions such as performing a mathematical procedure	◯	◯	◯	◯	◯
Extended response items for which students must justify a solution	◯	◯	◯	◯	◯
Performance tasks or events (i.e., hands-on activities)	◯	◯	◯	◯	◯
Individual or group presentation to teacher/class	◯	◯	◯	◯	◯
Portfolios	◯	◯	◯	◯	◯
Mathematics projects, other than those listed above	◯	◯	◯	◯	◯
Systematic observation of students	◯	◯	◯	◯	◯

Section 5 Barriers and Supports

36. The list below contains elements that may have HELPED or HINDERED implementation of the practices learned in the MSP Teacher Leadership Academies. Please indicate how each element has impacted your teaching your "over time". Consider "over time" to represent when you first began participation in the MSP Teacher Leadership Academies until present day.

	Significantly hindered	Slightly hindered	Had no effect	Slightly supported	Significantly supported
My content knowledge	◯	◯	◯	◯	◯
My pedagogical content knowledge (my understanding of best practices of instruction)	◯	◯	◯	◯	◯
Current scheduling practices in my school (i.e., traditional, block, etc.)	◯	◯	◯	◯	◯
Role of standardized assessments (PSSAs, Keystones, etc.)	◯	◯	◯	◯	◯
Instructional time	◯	◯	◯	◯	◯
Planning time	◯	◯	◯	◯	◯
The role of the textbook as a primary source in my class	◯	◯	◯	◯	◯
Providing different types of assessments (authentic, performance-based, etc.)	◯	◯	◯	◯	◯
Time provided for collaboration with colleagues	◯	◯	◯	◯	◯
My department/grade's expectation for teaching practices	◯	◯	◯	◯	◯
District leadership	◯	◯	◯	◯	◯
School leadership	◯	◯	◯	◯	◯
Parental support	◯	◯	◯	◯	◯
Instructional resources of which I have access	◯	◯	◯	◯	◯
Opportunities for on-going, focused professional development related to my work in the classroom	◯	◯	◯	◯	◯
MSP professional development, OTHER than the TLAs, of which I have participated	◯	◯	◯	◯	◯
My understanding of how my students learn mathematics	◯	◯	◯	◯	◯
My understanding of my role in my students' learning of mathematics	◯	◯	◯	◯	◯
The tracking of students into different math courses	◯	◯	◯	◯	◯
My belief in the importance of drill and practice with students in mathematics	◯	◯	◯	◯	◯
The value I place on collaboration with colleagues	◯	◯	◯	◯	◯
The curriculum (I feel as if I have to cover all of it to prepare students for the next grade level of course.)	◯	◯	◯	◯	◯
My beliefs about what a mathematics classroom should	◯	◯	◯	◯	◯

look like

My beliefs about how students learn mathematics	◯	◯	◯	◯	◯

Other (please explain)

Mathematical Instructional Practices in Southwestern PA

Interview Participation

37. Would you be willing to participate in a semi-structured interview for Phase 2 of this study?

- ◯ Yes
- ◯ No

Mathematical Instructional Practices in Southwestern PA

Interview Contact Information

38. If you are interested in participating in the semi-structured interviews, please provide your name and email address.

Mathematical Instructional Practices in Southwestern PA

Thank you for participating in my survey!

Thank you for participating in the survey. As previously indicated, your contributions will help to inform the study of professional development opportunities for math teachers.

As a "thank you" for your participation, you may be entered into a drawing. By completing this survey, you may win one of two $50 gift cards.

To register for the drawing, you will need to provide your contact information at the following independent website:

http://tinyurl.com/JRSurveyDrawing

Or, click "Done" to exit the survey.

APPENDIX C

Semi-Structured Interviews

Disclaimer: Although interview questions and prompts were identified, please note it was the purpose of the semi-structured interviews to be conversational and evolve based on what participants revealed. The questions and prompts indicated served as the framework for the semi-structured interview; however, these were approximations of the conversations that occurred. For the purposes of the semi-structured interview, the question and its accompanying prompts were condensed to bullets for the interviewer to use as a guide. Given the semi-structured interview's intent was to be conversational, at times the interviewer may have asked the interviewee to expand upon responses. This was done by the interviewer asking "Can you tell me more about that?"

Interview Question	Alignment to Research Question/Alignment to Literature/Alignment to Modified SEC Survey
1. Please describe your current role/position in your district. How do you define your amount of responsibility in providing mathematics instruction to students?	Q1 Modified SEC Q1, Q5, Q10, and Q12
2. Have you changed positions or district assignments since your participation in the	Q1

MSP's Teacher Leadership Academies? Describe the changes in your responsibility with regard to mathematics instruction.	Modified SEC Q10, Q13 and Q14
3. Where did you learn about the MSP Teacher Leadership Academies? a. Why did you elect to participate in the TLA? b. Did your experience in the TLAs affect your professional work with regard to mathematics instruction? If so, please describe. c. Does your work in the TLAs impact how you teach mathematics currently? If so, please describe. (Possible prompts for participants: Connection to PAC/Standards for Mathematical Practice, use of mathematical tasks with students, use of student dialogue, classroom learning environment, reflection of teaching and learning, etc.)	Q1 Modified SEC Q11, Q15 and Q16
4. Describe the types of instructional strategies you use when you teach mathematics. a. For each instructional strategy you identified, can you provide a concrete, specific example of an activity that depicts this strategy?	Q2 Hudson (2006) Brown (2003) Martinez (2001) Modified SEC Q30, Q31, Q32 and Q33
5. Describe the types of assessment strategies you use when you assess your students' understanding of mathematics? (Possible examples, true/false, multiple choice, open-ended, projects, portfolios, etc.) a. For each assessment strategy, can you	Q2 Hudson (2006) Brown (2003) Martinez (2001) Modified SEC Q34

provide concrete specific examples of assessments depicting this strategy?	
6. Please discuss if there have been changes to your classroom practice within the past 8-10 years in regard to: a. Your role as teacher b. The role of your students (how do your students participate in the learning of mathematics) c. The role of assessment	Q2; Q3 Anderson (1996) Johnson (2006) Briar (1999) Brown (2003) Martinez (2001) Modified SEC Q30, Q31, Q32, Q33, and Q34
7. Describe any instructional practices you use consistently. a. Why have you continued to use these practices? Please explain.	Q2; Q3 *Surveys of Enacted Curriculum* (2001) Blank (2002) Brown (2003) Geist (2000) Martinez (2001) Anderson (1996) Johnson (2006) Modified SEC Q30, Q31, Q32, Q33, Q34, and Q35
8. Have there been any instructional practices that you are interested in implementing; however, you do not currently use? If so, please identify such practices. a. Why have you not implemented these practices? Which of the following, if any, have had the greatest impact on your decision not to implement such instructional practices? If so, please explain. School level (administrative support, climate, time, scheduling,	Q2; Q3 Anderson (1996) Johnson (2006) Fullan (2000) Modified SEC Q35

resources and materials, etc.) District level (administrative support, curriculum, resources and materials, etc.) External factors (standardized testing, accountability, AYP, etc.) Professional development experiences (Both MSP and non-MSP)	
9. Describe how an observation of your class conducted today might be similar or different than an observation of your class conducted 8-10 years ago.	Q2 Geist (2000) Brown (2003) Martinez (2001)
10. In reflecting upon the last 8-10 years, which of the following were the most significant in terms of impacting how you teach mathematics. a. Administrative support (Political). Please describe b. Opportunities for professional development related to your content area (Technical). Please describe. c. Available resources (Political). Please describe. d. Collaboration (Political). Please describe. e. The school climate overall (Cultural). Please describe. f. Outside forces (Parents, technology, policies, etc.) (Political). Please describe.	Q3 Supovitz, J.A. Mayer, D.P. & Kahle, J.B. (2000) Anderson (1996) Johnson (2006) Fullan (2000) Modified SEC Q35
11. Over the past 10 years, please describe	Q1; Q3

your involvement and participation in professional development opportunities. a. Can you provide specific examples of these opportunities? b. What was your role in each of these professional development experiences?	Supovitz, J.A. Mayer, D.P. & Kahle, J.B. (2000) Anderson (1996) Johnson (2006) Modified SEC Q35

APPENDIX D

INTRODUCTION AND FOLLOW UP LETTERS

Introductory Email to Recruit Participants in Study

Jackie (Anderson) Removcik
183 Heather Dr.
Monroeville, PA 15146
412-302-4356
jremovcik@wiu.k12.pa.us

Dear Educator,

I am emailing to invite you to participate in a research study on the long-term use of standards-based instructional mathematics practices occurring in classrooms. My name is Jackie (Anderson) Removcik, and I am a doctoral candidate in the School of Education's Administrative and Policy Studies Program at the University of Pittsburgh. I am interested in exploring the professional experiences and career trajectories of teachers who participated in the Math Science Partnership's (MSP) Mathematics Teacher Leadership Academies (TLAs), the long-term use of standards-based instructional practices in mathematics classrooms, and the exploration of barriers and supports that contributed to the long-term use of standards-based practices. I intend to survey a sample of secondary mathematics teachers who have participated in the MSP Teacher Leadership Academies from 2004-2008. As a result of the work in this study, I wish to learn:

1. What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?

2. What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?

3. For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?

This research study consists of an online survey administered through Survey Monkey. Participation in this study is voluntarily, and the survey should take approximately 20-25 minutes to complete.

There are two phases for this study. Phase 1 is the completion of this survey. Phase 2 consists of semi-structured interviews that will be conducted at a later date. Participation in the semi-structured interviews is also voluntary. Once the survey is complete, you will be asked if you are willing to participate in Phase 2 of this study. If yes, you will then be asked to provide your contact information. There will then be a possibility that the researcher will contact you after the survey closes to arrange for the semi-structured interview.

Please be assured all your survey responses will remain confidential. Any participants who complete the survey will be assigned random ID numbers in order to protect the confidentiality of responses. Any identifying information collected in this survey will not be used in any of the reporting and analysis of the data. Please be assured that you are not obligated to participate in any of the phases of this study.

In addition, there is also an incentive for participation in this study. As an incentive and thank you for taking the survey, you can enter a drawing for one of two $50 VISA gift cards. Upon completion of the survey, you will be directed to a separate URL where can register your name, email and mailing address for entrance into the drawing. The gift cards will be mailed to the winners approximately two weeks after the close of the survey. The deadline for completion of this survey is **Friday, October 11, 2013**. Please use the link below to complete the survey. Thank you for your participation, and please do not hesitate to contact me if you have any questions regarding this study.

https://www.surveymonkey.com/s/RVSVW97

Sincerely,

Jackie (Anderson) Removcik

Follow up Email to Recruit Participants in Study

Jackie (Anderson) Removcik
183 Heather Dr.
Monroeville, PA 15146
412-302-4356
Jla62@pitt.edu

Dear Educator,

You may recall that I recently sent you an introductory email asking for your help in a research study that I am conducting for my doctoral studies. Contained within this email was a link for an online survey. This online survey will only take approximately 20-25 minutes of your time. I intend to survey a sample of individuals who have participated in the MSP Teacher Leadership Academies. The survey contains questions related to your professional experiences and classroom experiences. **Please note that even if you are not currently teaching mathematics you are still eligible to complete the survey.**

As a result of the work in this study, I wish to learn:

1. What have been the career trajectories and professional experiences of teachers who participated in the MSP TLAs in regard to their current role and district since their participation in the TLAs?

2. What are teachers' self-reported perceptions of their long-term use of standards-based instructional practices after they participated in the MSP TLAs?

3. For participants of the TLAs, what are teachers' self-reported perceptions of barriers and supports that have affected the continued use of standards-based practices in their mathematics classrooms over time?

Please be assured there is minimal risk to participants in this study as all responses will be confidential, and you may opt out of this survey at any time. Further, results of this study will be available if you wish to request them. Your contribution to this study will help to perpetuate the discourse of how the use of standards-based instructional mathematics classrooms may be supported over time.

There is a Phase 2 of this research study which consists of semi-structured interviews that will be conducted at a later date. Participation in the semi-structured interviews is also voluntary. Once the survey is complete, you will be asked if you are willing to participate in Phase 2 of this study. If yes, you will then be asked to provide your contact information. There will then be a possibility that the researcher will contact you after the survey closes to arrange for the semi-structured interview.

To express my appreciation for your participation in this survey, you may provide your contact information to be entered into a random drawing for one of two $50 gift cards. The gift cards will be mailed to winners within one month of the close of the survey window. At the end of the survey, you will be provided a separate URL address that you may use to enter the drawing. If you are willing to participate, then please complete the online survey at the following web address: https://www.surveymonkey.com/s/RVSVW97. Your response to this is greatly appreciated. All surveys must be completed by **Friday, October 11, 2013.**

Thank you again for your assistance,

Jackie (Anderson) Removcik

Introductory Email to Recruit Participants in Semi-Structured Interviews of Study

Jackie (Anderson) Removcik
183 Heather Dr.
Monroeville, PA 15146
412-302-4356
jremovcik@wiu.k12.pa.us

Dear Mathematics Educator,

A few weeks ago, you completed a survey for my research study regarding the use of standards-based instructional practices occurring in mathematics classrooms. Thank you for your assistance with the survey portion of this research study.

In that survey, you indicated that you would be willing to participate in Phase 2 of this research which involves semi-structured interviews. I am contacting you to see if you are still willing to participate in the semi-structured interview portion of this study. The semi-structured interviews consist of approximately 10-11 questions. The interview should take approximately 30-45 minutes to complete, and there is no more than minimal risk to individuals who participate in this research. Please note that the interviews for this research study will be audio taped and transcribed; however, your name will not be used. Rather, you will be given a code and pseudonym to ensure confidentiality of your responses. Pseudonyms will be used in both the reporting and analysis of the data, and all identifying information will be changed for any written reports. Your participation is voluntary, and you may withdraw at any time, for any reason, without penalty.

I am looking to begin conducting these interviews in November, and I would like to make arrangements to schedule this interview**. I can make myself available November 6, 7, 12, 15 or 19th, and I can come to you. If you could respond to this email by Friday, November 1, and let me know 2 dates (of those identified) that would work for you, I would *greatly* appreciate it.**

Thank you for volunteering to participate in a semi-structured interview. By agreeing to participate in the semi-structured interview, you acknowledge the above information and give your voluntary consent for participation. You have my sincere appreciation for your participation in this study, and I believe that your contributions will assist in providing high-quality professional development experiences to mathematics teachers.

Sincerely,

Jackie (Anderson) Removcik

APPENDIX E

Semi-Structured Interview Codebook

Assessment ~ changes: How has assessment changed in the last 8-10 years

Assessment of students: How are students assessed in the courses, especially application level questions requiring students to explain the method they used to solve a problem and why they chose that method

1. Formative- Used to determine what students' understand and what re-teaching is needed (Use of whiteboards, signaling, exit tickets)
2. Summative-Quizzes & Tests

Colleague collaboration: Formal or informal collaboration with other teachers on issues of curriculum, instruction and assessment

Current Role: Current position; courses currently taught

Curriculum change: Overall curriculum change in the school district/school

Instructional activities/strategies: Activities, practices, and strategies used by teacher (ex: foldables, collaboration)

1. Student Collaboration-Working with a partner or small group Student Collaboration-Working with a partner or small group
2. Multiple Methods/Solutions-Options for solving problems; solving problems in different ways
3. Tasks-items that engage students' intellect, develop students' mathematical understandings and skills, stimulate students to make connections and develop a coherent framework for mathematical ideas; call for problem formulation, problem solving, and mathematical reasoning, promote communication about mathematics, represents mathematics as an on-going human activity, display sensitivity to, and draw on, students' diverse background experiences and dispositions; promotes the development of all students' dispositions to do mathematics. (NCTM, Principles and Standards for School

Mathematics) Allows for multiple methods; contextual; provides time for both individual think time and collaboration; presentation of solutions to tasks; A series of tasks could cover a unit and the major ideas within that unit

4. Presentation of Solutions- Presenting solutions and discussion about different methods used to obtain those answers
5. Planning Time-Time for instructional planning both common and not
6. Questioning-Pre-determined and planned questions to scaffold learning and push students further in their learning
7. Technology- How technology is used to enhance the classroom learning environment, particularly allowing students to research how to solve and find different methods and sharing those with the class
8. Role of Teacher- Level of “control” teacher provides
9. Teacher Feedback-Feedback provided to students to in regard to their learning
10. Teacher Expectations-Reasonable teacher expectations for their students

Instructional activities/strategies ~ changes: Any changes in last 8-10 years.

Note: if no changes indicated, also include a comment.

Instructional activities/strategies ~ Coverage: Covering all content as other teachers or as on an assessment such as the PSSAs or AP exam; Covering everything in the curriculum

Instructional activities/strategies ~ Level of Thinking: Level of Bloom’s taxonomy addressed, particularly the higher levels of thinking.

Instructional activities/strategies ~ Student-centered instruction: Students have more control of their learning; they are active and engaged in hands-on tasks; Teacher scaffolding questions for students to ensure they continue with the task and advance their learning

Instructional activities/strategies ~ Teacher-centered instruction: Lecture based; teacher provided the examples; “I do, we do, you do” model

Instructional practices/activities/strategies ~ benefits: Any benefits by using particular activities/strategies in the classroom

Instructional practices/activities/strategies ~ problems/barriers: Any problems or frustrations with carrying out activities/strategies (student focus; comfort level of instructor) or reasons that practices are difficult to try and/or maintain.

Leadership positions: Any special positions or leadership roles (chair of math department, head of a consortium, etc.); including assisting in disseminating information; providing curricular and professional development support and assistance

Math courses: Math courses that the teacher regularly teaches; amount of responsibility for providing solely mathematics instruction

MSP ~ initial introduction: How learned about MSP

MSP ~ years: Length of time of participation in MSP math TLAs

Other

Other courses: Other courses that the teacher teaches regularly

Professional Development: Seminars, courses, colloquiums, etc. that focus on professional development

1. District Professional Development-Professional development opportunities provided locally within the district (i.e. Communities of Practice, etc.)
2. External Professional Development-Professional development structures provided by external sources (classes, MSP, etc.); Professional development not offered by the district

Reason for Participation: Factors contributing to why joined TLAs

Sources and confidence of new activities/strategies: Where teacher gets ideas for activities and strategies and the teacher's confidence level when implementing new practices

Student learning: Changes in how students are learning; students' desires in how to learn

1. Prior Knowledge-What students already know and possible misconceptions
2. Student Behavior Concerns-Off task behaviors during tasks
3. Skills-Basic mathematical skills students are already expected to know and be able to do
4. Student Feedback-Student feedback elicited from students

Teaching experience: Years, location, and title of teaching experience; changing roles (ex: from math to science teaching, etc.)

Testing/Accountability: External assessments such as PSSA/Keystone and how these impact building and teacher evaluations, as well as how they affect the classroom activities and other issues with these external assessments such as the stress experienced by the students associated with them

APPENDIX F

Chi-square results

Table 39: Chi-square results for Table 2

Different roles/positions	χ^2	*d.f.*	*p*
Taught mathematics	0.857	4	1.000
Taught mathematics at current school	0.857	4	1.000
Held a teacher leadership position (i.e., department chair, curriculum leader, etc.)	0.857	4	1.000
Held a building level leadership position (assistant principal or principal	4.571	2	0.136
Held a district level leadership position (assistant superintendent, director, supervisor superintendent)	2.000	2	0.520
Held a leadership position outside of a school district (i.e., curriculum director at an IU)	4.571	2	0.136

Table 40: Chi-square results for Table 21

Factors	χ^2	*d.f.*	*p*
Common Core/PA Core	0.000	3	1.000
Standards for Mathematical Practice	0.500	2	1.000
Role of mathematical tasks with students	0.000	3	1.000
Role of student dialogue in mathematics	0.000	3	1.000
Structuring the classroom environment for the learning of mathematics	0.000	3	1.000
Role of reflection in teaching	0.000	3	1.000

Table 41: Chi-square results for Table 22

Factors	χ^2	*d.f.*	*p*
Common Core/PA Core	0.667	3	1.000
Standards for Mathematical Practice	0.667	4	1.000
Role of mathematical tasks with students	2.000	3	0.736
Role of student dialogue in mathematics	2.000	3	0.736
Structuring the classroom environment for the learning of mathematics	2.000	3	0.736
Role of reflection in teaching	2.000	3	0.736

Table 42: Chi-square results for Table 23

Factors	χ^2	*d.f.*	*p*
Common Core/PA Core	0.667	4	1.000
Standards for Mathematical Practice	0.667	4	1.000
Role of mathematical tasks with students	2.000	3	0.736
Role of student dialogue in mathematics	2.000	3	0.736
Structuring the classroom environment for the learning of mathematics	0.667	3	1.000
Role of reflection in teaching	2.000	3	0.736

Table 43: Chi-square results for Table 26

Instructional Practice	χ^2	*d.f.*	*p*
Watch the teacher demonstrate how to do a procedure or solve a problem	2.000	3	0.736
Read about mathematics in books, magazines or articles (not including textbooks)	2.000	3	0.736
Take notes from lectures or textbook	0.000	2	1.000
Complete computational exercises or procedures from a textbook or worksheet	2.000	3	0.736
Present or demonstrate solutions to a math problem to the whole class	0.667	4	1.000
Use manipulatives (i.e., geometric shapes or algebraic tiles), measurement instruments (i.e., rulers or protractors), and data collection devices (i.e., surveys or probes)	0.667	4	1.000
Work on mathematical investigations or tasks	0.667	4	1.000
Do mathematics activities with the class outside of the classroom	0.667	4	1.000
Use computers, calculators, or other technology to learn mathematics	1.000	2	0.877
Maintain and reflect a portfolio of their own work	0.667	4	1.000

Table 44: Chi-square results for Table 27

Instructional Practice	χ^2	*d.f.*	*p*
Watch the teacher demonstrate how to do a procedure or solve a problem	0.667	4	1.000
Read about mathematics in books, magazines or articles (not including textbooks)	2.000	3	0.736
Take notes from lectures or textbook	0.667	4	1.000
Complete computational exercises or procedures from a textbook or worksheet	1.000	2	0.877
Present or demonstrate solutions to a math problem to the whole class	0.667	4	1.000
Use manipulatives (i.e., geometric shapes or algebraic tiles), measurement instruments (i.e., rulers or protractors), and data collection devices (i.e., surveys or probes)	1.000	2	0.877
Work on mathematical investigations or tasks	0.667	4	1.000
Do mathematics activities with the class outside of the classroom	0.667	4	1.000
Use computers, calculators, or other technology to learn mathematics	0.667	4	1.000
Maintain and reflect a portfolio of their own work	0.000	2	1.000

Table 45: Chi-square results for Table 28

Instructional Practice	χ^2	*d.f.*	*p*
Watch the teacher demonstrate how to do a procedure or solve a problem	0.667	4	1.000
Read about mathematics in books, magazines or articles (not including textbooks)	2.000	3	0.736
Take notes from lectures or textbook	0.667	4	1.000
Complete computational exercises or procedures from a textbook or worksheet	0.667	3	1.000
Present or demonstrate solutions to a math problem to the whole class	2.000	3	0.736
Use manipulatives (i.e., geometric shapes or algebraic tiles), measurement instruments (i.e., rulers or protractors), and data collection devices (i.e., surveys or probes)	0.667	4	1.000
Work on mathematical investigations or tasks	0.667	4	1.000
Do mathematics activities with the class outside of the classroom	0.667	4	1.000
Use computers, calculators, or other technology to learn mathematics	0.667	4	1.000
Maintain and reflect a portfolio of their own work	2.000	3	0.736

Table 46: Chi-square results for Table 29

Instructional Practice	χ^2	*d.f.*	*p*
Solve word problems from a textbook or worksheet	2.000	3	0.736
Solve non-routine mathematical problems (i.e., problems that require novel or non-formulaic thinking)	0.667	4	1.000
Talk about their reasoning or thinking in solving a problem, using several sentences orally or in writing	0.667	4	1.000
Apply mathematical concepts to "real-world" problems	0.667	4	1.000
Make estimates, predictions, or hypotheses	2.000	3	0.736
Analyze data to make inferences or draw conclusions	0.000	2	1.000
Complete or conduct proofs or demonstrations of their mathematical thinking	2.000	3	0.736

Table 47: Chi-square results for Table 30

Instructional Practice	χ^2	*d.f.*	*p*
Solve word problems from a textbook or worksheet	1.000	2	0.877
Solve non-routine mathematical problems (i.e., problems that require novel or non-formulaic thinking)	1.000	2	0.877
Talk about their reasoning or thinking in solving a problem, using several sentences orally or in writing	0.667	3	1.000
Apply mathematical concepts to "real-world" problems	1.000	2	0.877
Make estimates, predictions, or hypotheses	0.667	4	1.000
Analyze data to make inferences or draw conclusions	0.667	4	1.000
Work on a problem that takes at least 45 minutes to solve	0.667	4	1.000
Complete or conduct proofs or demonstrations of their mathematical thinking	0.667	3	1.000

Table 48: Chi-square results for Table 31

Instructional Practice	χ^2	*d.f.*	*p*
Work with manipulatives (i.e., counting blocks, geometric shapes, or algebraic tiles) to understand mathematical concepts	1.000	2	0.877
Build models or charts	0.667	4	1.000
Present information to others using manipulatives (i.e., chalkboard, whiteboard, posterboard or projector)	0.667	4	1.000

Table 49: Chi-square results for Table 32

Assessment Technique	χ^2	*d.f.*	*p*
Objective items (i.e., multiple choice, true/false)	0.000	4	1.000
Short answer questions such as performing a mathematical procedure	0.600	3	1.000
Extended response items for which students must justify a solution	0.600	3	1.000
Performance tasks or events (i.e., hands-on activities)	0.600	3	1.000
Individual or group presentation to teacher/class	0.000	4	1.000
Portfolios	0.600	3	1.000
Mathematics projects, other than those listed above	0.600	3	1.000
Systematic observation of students	0.600	3	1.000

Table 50: Chi-square results for Table 33

Factor	χ^2	*d.f.*	*p*
My content knowledge	0.000	2	1.000
My pedagogical content knowledge (my understanding of best practices of instruction)	0.000	2	1.000
Current scheduling practices in my school (i.e., traditional, block, etc.)	0.000	2	1.000
Role of standardized assessments (PSSAs, Keystones, etc.)	0.000	2	1.000
Instructional time	0.000	2	1.000
Planning time	0.000	2	1.000
The role of the textbook as a primary source in my class	0.000	2	1.000
Providing different types of assessments (authentic, performance-based, etc.)	0.000	2	1.000

Table 51: Chi-square results for Table 34

Factor	χ^2	*d.f.*	*p*
Time provided for collaboration with colleagues	0.000	2	1.000
District leadership	0.000	2	1.000
School leadership	0.000	2	1.000
Parental support	0.000	2	1.000
Instructional resources of which I have access	0.000	2	1.000

Table 52: Chi-square results for Table 35

Factor	χ^2	*d.f.*	*p*
My department/grade's expectation for teaching practices	0.000	2	1.000
The tracking of students into different math courses	0.333	1	1.000
My belief in the importance of drill and practice with students in mathematics	0.000	2	1.000
The value I place on collaboration with colleagues	0.000	2	1.000
My beliefs about what a mathematics classroom should look like	0.000	2	1.000
My beliefs about how students learn mathematics	0.000	2	1.000

Table 53: Chi-square results for Table 36

Factor	χ^2	*d.f.*	*p*
Opportunities for on-going, focused professional development related to my work in the classroom	0.000	2	1.000
MSP professional development, OTHER than the TLAs, of which I have participated	0.000	2	1.000

BIBLIOGRAPHY

Alsup, J. (2005). A comparison of constructivist and traditional instruction in mathematics. *Education Research Quarterly, 28*(4), 3-17.

Anderson, R.D. (1996). *Study of curriculum reform. Vol. 1: Findings and conclusions*. Studies of Educational Reform. (ERIC Document Reproduction Service No. ED 397535).

Battista, M. T. (2001). Research and reform in mathematics education. In T. Loveless (Ed.), The great curriculum debate: How should we teach reading and math? (pp. 42–84). Washington, DC: Brookings Institution.

Battey, D. & Franke, M.L. (2008). Transforming identities: Understanding teachers across professional development and classroom practice. *Teacher Education Quarterly, 35*(3), 127-149.

Blank, R.K. (2002). Using Surveys of Enacted Curriculum to advance evaluation of instruction in relation to standards. *Peabody Journal of Education, 77*(4), p. 86-121.

Briars, D.J. (1999). Curriculum and systemic math reform. *The Education Digest, 64*(7), 22.

Brown, D.M. (2003). Learner-centered conditions that ensure students' success in learning. *Education, 124*(1), 99-104.

Botkin, E., Adams, J., & Price, R. (2009). Math Science Partnership of Southwest Pennsylvania: An evaluation of Eyes on Science & Lenses on Learning. Pittsburgh, PA: University of Pittsburgh, School of Education, Collaborative for Evaluation and Assessment Capacity.

Buckley, J. (2012). Highlights form PIRLS and TIMSS 2011. Retrieved from National Center for Education Statistics website: http://nces.ed.gov/timss/results11.asp.

Bunt, N. (2006). PI Narrative for annual report: SWPA MSP, Year 3. Retrieved from Math Science Partnership website: http://hub.mspnet.org/media/data/SWPA_2006_Annual_Report_to_NSF.pdf?media_000000005929.pdf.

Bunt, N.R. (2010). Sustaining momentum for improvement. Retrieved from Math Science Partnership website: http://hub.mspnet.org/media/data/44_-_Bunt.pdf?media_000000006558.pdf.

Council of Chief State School Officers & Wisconsin Center for Education Research. (2001). *Surveys of Enacted Curriculum: Tools and services to assist educators*. Washington, D.C. Retrieved January 6, 2013 from https://secure.wceruw.org/seconline/Reference/K12mthSurvey.pdf.

Council of Chief State School Officers. (2013). Common Core state standards initiative. Retrieved March 19, 2013 from http://www.corestandards.org/resources/key-points-in-mathematics

Cuban, L. (2001). How did teachers teach: 1890-1980. *Theory into Practice*, *23*(3), 159-165.

Cohen, D.K. & Ball, D.L. (1990). Policy and practice: An overview. *Educational Evaluation and Policy Analysis*, 12(3), 233-239.

Creswell, J.W. (2009). Research Design: *Qualitative, Quantitative, and Mixed Methods Approaches*. 3rd ed. Thousand Oaks, CA: Sage Publications.

Darling-Hammond, L. (1998). Teacher learning that supports student learning. *Educational Leadership, 55*(5), 6-11.

Darling-Hammond, L. (2007). We need to invest in math and science teachers. *The Chronicle of Higher Education, 54*(17), p. 20-22.

Darling-Hammond, L., Wei R. C., Andree, A., Richardson, N. & Orphanos, S. (2009). State of the profession. *National Staff Development Council*, 30(2), 42-50.

Ellis, M. (2008). Leaving no child behind yet allowing none too far ahead: Ensuring (in)equity in mathematics education through the science of measurement and instruction. *Teacher's College Record*, *110*(6), pp. 1330-1356.

Elmore, R.F. (1995). Structural reform and educational practice. *Educational Researcher, 24*(9), p. 23-26.

Fullan, M. (2000). The Three Stories of Education Reform. *The Phi Delta Kappan, 81*(8), 581-584.

Fullan, M. (2007). *The new meaning of educational change.* 4th ed. New York, NY: Teachers College Press.

Ferrini-Mundy, J. & Martin, W.G. (2007). Using research in policy development: The case of the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics. In J. Kilpatrick, W.G. Martin & D. Schifter (Eds.), *A research companion to principles and standards for school mathematics.* (pp. 5-23). Reston, Virginia: National Council of Teachers of Mathematics.

Fleischman, H.L, Hopstock, P.J., Pelczar, M.P., & Shelley, B.E. (2010). Highlights from PISA 2009: Performance of U.S. 15-Year-Old Students in Reading, Mathematics, and Science Literacy in an International Context. Washington, DC: National Center for Education Statistics. Retrieved March 13, 2013 from http://nces.ed.gov/pubs2011/2011004.pdf.

Gamoran, A., Anderson, C.W., Quiroz, P.A., Secada, W.G., Williams, T., & Ashmann, S. (2003). Transforming teaching math and science: How schools and districts can support change. New York: Teachers College Press.

Garet, M. S., Porter, A.C., Desimone, L., Birman, B.F., & Yoon, K.S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Geist, E.A. (2000). Lessons from the TIMSS videotape study. *Teaching Children Mathematics, 7*(3), 180.

General Assembly of the Commonwealth of Pennsylvania. (1997). Intermediate Units in Pennsylvania: The role of educational service agencies in promoting equity in basic education. Retrieved August 11, 2013 from http://files.eric.ed.gov/fulltext/ED416577.pdf.

Gigante, N.A. & Firestone, W.A. (2007). Administrative support and teacher leadership in schools implementing reform. *Journal of Educational Administration*, *46*(3), 302-331.

Goodlin, M., Johnson, G., Olenik, N., Kirby McConnell, L., & Yugar, Y. (2009). MSP teacher content knowledge: 2004-2010. Pittsburgh, PA: Allegheny Intermediate Unit.

Greeno, J. G., Middle-School Math Applications Project Group, & The Middle-School Mathematics through Applications Project Group. (1997). Theories and practices of thinking and learning to think. *American Journal of Education*, *106*(1), 85-126. doi:10.1086/444177

Guskey, T.R. (2003). Professional development that works: What makes professional development effective? *Phi Delta Kappan*, *84*(10), 748-750.

Herrera, T.A. & Owen, D.T. (2001). The "new new math"?" Two reform movements in mathematics education. *Theory into Practice*, *40*(2), 84-92.

Hiebert, J. & Stigler, J.W. (2000). A proposal for improving classroom teaching: Lessons from the TIMSS video study. *The Elementary School Journal*, *101*(1), 3-20.

Hiebert, J. (2007). What research says about the NCTM Standards. In J. Kilpatrick, W.G. Martin & D. Schifter (Eds.), *A research companion to principles and standards for school mathematics*. (pp. 5-23). Reston, Virginia: National Council of Teachers of Mathematics.

Hill, H.C. (2009). Fixing teacher professional development: A broken system of professional learning requires decisive action to ensure wise expenditure of limited resources. *Phi Delta Kappan, 90*(7), 470-477.

Hill, H., Schilling, S.G., & Ball, D.L. (2004). Developing measures of teachers' mathematical knowledge for teaching. *The Elementary School Journal, 105*(1), 11-30.

Hofmesiter, A.M. (2004). Education reform in mathematics: A history ignored? *Journal of Direct Instruction, 4*(1), 5-11.

Howley, A., Larson, W., Solange, A., Rhodes, M., & Howley, M. (2007). Standards-based reform of mathematics education in rural high schools. Journal of Research in Rural Education, 22(2). Retrieved August 1, 2013 from http://jrre.psu.edu/articles/22-2.pdf.

Huck, S.W. (2012). *Reading statistics and research*. Boston, MA: Pearson.

Hudson, P., Miller, S.P., & Butler, F. (2006). Adapting and merging explicit instruction within reform based mathematics classrooms. *American Secondary Education, 35*(1), 19-32.

Huffman, D., Thomas, K., & Lawrenz, F. (2008). Science and mathematics instruction in a reform-based teacher preparation program. *School Science and Mathematics, 108*(4), 137-148.

Hurd, J., Lewis, C., O'Connell, M.P., & Perry, R. (2006). Lesson study comes of age in North America. *Phi Delta Kappan, 88*(4), 273-281.

Jaramillo, J.A. (1996). Vygotsky's sociocultural theory and contributions to the development of constructivist curricula. *Education, 117*(1), 133-140.

Jakwerth, P. (1999). TIMSS performance assessment results United States. *Studies in Educational Evaluation, 25*(3), 277-281.

Johnson, C.C. (2006). Effective professional development and changes in practice: Barriers science teachers encounter and implications for reform. *School Science and Mathematics, 106*(3), 150-161.

Joint State Government Commission. (1997). Intermediate Units in Pennsylvania: The role of educational service agencies in promoting equity in basic education. Harrisburg: PA, General Assembly of the Commonwealth of Pennsylvania. Retrieved August 13, 2013 from http://jsg.legis.state.pa.us/resources/documents/ftp/publications/1997-89-IUREPORT.PDF.

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Thousand Oaks, Calif: Sage Publications Inc.

Lewis, C., Perry, R., & Hurd, J. (2004). A deeper look at lesson study. *Educational Leadership, 61*(5), 18-22.

Loucks-Horsley, S. & Matsumoto, C. (1999). Research on effective professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*(5), 258-271.

Malik, L. (2004). What are we doing: Secondary Mathematics Teacher Leadership Academy. *Math & Science Collaborative Journal, 10*, 39-40.

Martinez, J.G.R. (2001). Exploring, inventing, and discovering mathematics: A pedagogical response to the TIMSS. *Mathematics Teaching in the Middle School, 7*(2), 114-119.

Math & Science Collaborative (2012). Vision and mission of MSC and the MSC Steering Council. Retrieved April 10, 2016 from http://www.aiu3.net/uploadedFiles/Teaching_and_Learning/Math_and_Science_Collaborative/2011-2012%20Vision%20of%20the%20MSC.pdf.

Mertens, D. (2010). *Research and evaluation in educational psychology: Integrating diversity with quantitative, qualitative, and mixed methods.* 3rd ed. Thousand Oaks, CA: Sage Publications.

Mewborn, D.S. (2007). Teaching, teachers' knowledge, and their professional development. In J. Kilpatrick, W.G. Martin & D. Schifter (Eds.), *A research companion to principles and standards for school mathematics.* (pp. 5-23). Reston, Virginia: National Council of Teachers of Mathematics.

Moreira, P. & David, M. (2008). Academic mathematics and mathematical knowledge needed in school teaching practice: Some conflicting elements. *Journal of Math Teacher Education, 11*(1), 23-40.

National Center for Education Statistics. (2013). *Trends in International Mathematics and Science Study (TIMSS).* Retrieved January 2012 from http://nces.ed.gov/TIMSS/index.asp.

National Council of Teachers of Mathematics. Commission on Teaching Standards for School Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: The Council.

National Governors Association Center for Best Practices & Council of Chief State School Officers. *Common Core State Standards Mathematics*. Washington, DC: National Governors Association Center for Best Practices & Council of Chief State School Officers.

National Science Foundation, Arlington, VA. Directorate for Education and Human Resources. (2006). Math and science partnership program: Strengthening America by advancing academic achievement in mathematics and science. NSF-05-069. *National Science Foundation.*

Normore, A.H. & Brooks, J.S. (2012). Instructional leadership in the era of No Child Left Behind: Perspectives from the United States. In L. Volante (Ed.), *School leadership in the context of standards-based reform: Studies in educational leadership.* DE: Springer Verlag.

Rampey, B.D., Dion, G.S., & Donahue, P.L. (2009). NAEP 2008 trends in academic progress (NCES 2009-479). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

Rea, L.M. & Parker, R.A.(2005). *Designing and conducting survey research: A comprehensive guide* . 3rd ed. San Francisco, CA: Jossey-Bass.

Robelen, E. (2010). Stem education to get boost from Race to the Top winners. *Education Week*. Retrieved August 28, 2011 from http://blogs.edweek.org/edweek/curriculum/2010/08/stem_education_to_get_big_boos.html.

Rubin, H.J. & Rubin, I.S. (2005). *Qualitative interviewing: The art of hearing data*. 2nd ed. Thousand Oaks, CA: Sage Publications.

Pane, J. F., Williams, V. L., Olmsted, S. S., Yuan, K., Spindler, E., Slaughter, M. E., & RAND Education. (2009). *Math science partnership of southwest Pennsylvania: Measuring progress toward goals. monograph.* RAND Corporation.

Pelkowski, T. & Wang Y. (2010). Math Science Partnership of Southwest Pennsylvania: Case study report. Pittsburgh, PA: University of Pittsburgh, School of Education, Collaborative for Evaluation and Assessment Capacity.

Pennsylvania Department of Education. (2013). PA Common Core Standards. Retrieved March 19, 2013 from http://www.pdesas.org/Standard/CommonCore.

Perry, R. R. & Lewis, C.C. (2009). What is successful adaptation of lesson study in the US? *Journal of Educational Change, 10*(4), 365-391.

Pfeffer, J. & Sutton, R.I. (2000). The knowing-doing gap: How smart companies turn knowledge into action. Boston, MA: Harvard Business School Press.

Schoenfeld, A.H. (2004). The math wars. *Educational Policy*, 18(1), 253-286.

Smithson, J. & Blank, R. (2006). Indicators of quality of teacher professional development and instructional change using data from surveys of enacted curriculum: Findings from NSF MSP-RETA project. Retrieved April 1, 2013 from http://jsmithson.wceruw.org/Reference/Indicators_TchrPD_Smithson-Blank.pdf.

Steele, J., Pane, J.F., Williams, V.L., Olmsted, S.S. (2006). Professional development participation and the role of the administrator involvement in the Math Science Partnership of Southwestern Pennsylvania. Retrieved from Math Science Partnership website February 26, 2013 at http://www.rand.org/content/dam/rand/pubs/working_papers/2006/RAND_WR428.pdf.

Stein, M.K, Smith, M.S. & Silver, E.A. (1999). The development of professional developers: Learning to assist teachers in new settings and in new ways. *Harvard Educational Review*, *69*(3), 237-269.

Stigler, J.W. & Hiebert, J. (1997). Understanding and improving classroom mathematics instruction. *Phi Delta Kapplan, 79*(1), 14-22.

Stigler, J.W. & Hiebert, J. (2004). Improving Mathematics Teaching. *Educational Leadership*, *61*(5), 12-17.

Supovitz, J.A. Mayer, D.P. & Kahle, J.B. (2000). Promoting inquiry-based instructional practice: The longitudinal impact of professional development in the context of systemic reform. *Educational Policy*, *14*(3), 331-357.

Taylor, A.R., Anderson, S., Meyer, K., Wagner, M.K., & West, C. (2005). Lesson study: A professional model for mathematics reform. *The Rural Education*, *26*(2), 17-22.

Tananis, C. (2005). Using evaluation as a bridge for partnership development. Retrieved from Math Science Partnership website: http://hub.mspnet.org/media/data/Tananis.pdf?media_000000006101.pdf.

Tananis, C. (2010). Math Science Partnership of Southwest Pennsylvania: Evaluator's report: Overall Findings. Pittsburgh, PA: University of Pittsburgh, School of Education, Collaborative for Evaluation and Assessment Capacity.

Timmerman, M.A. (2003). Perceptions of professional growth: A mathematics teacher educator in transition. *School Science and Mathematics*, *103*(3), 155-167.

Tyler, J.H., & Vitanova, S. (2008). Does MSP participation increase the supply of math teachers? Developing and testing an analytic model. *Peabody Journal of Education*, *83*(4)-536-561.

United States. Congress. House. Committee on Science. Subcommittee on Research. (2004). *Implementation of the math and science partnership program: Views from the field:*

Hearing before the subcommittee on research of the committee on science, house of representatives, one hundred eighth congress, first session, October 30, 2003. Washington: U.S. G.P.O.

Walker, E.N. (2007). Rethinking professional development for elementary mathematics teachers. *Teacher Education Quarterly, 34*(3), 113-134.

Williams, V.L., Pane, J.F., Tananis, C.A., & Olmsted, S.S. (2005). Math science partnership of Southwestern Pennsylvania: Year two evaluation report (Working Paper No. WR-270-EDU). Pittsburgh, PA: RAND Corporation

Williams, V.L., Pane, J.F., Tananis, C.A., Olmsted, S.S., & Ciminillo (2006). Math science partnership of Southwestern Pennsylvania: Year three evaluation report (Working Paper No. WR-396-AIU. Pittsburgh, PA: RAND Corporation

Wong, K.W. & Socha, T. (2008). A pilot study to identify comparison schools for math and science partnership participating schools: Preliminary findings on one math/science partnership. *Peabody Journal of Education, 83*(4), p. 654-673.

Wong, K.K., Yin, R.K., Moyer-Packenham, P.S., & Scherer, J. (2008). Introduction to the MSP-PE special issue on Math and Science Partnership Program: A first comprehensive evaluation. *Peabody Journal of Education, 83*(4), 479-485.

Yin, R. K. (2008). The math and science partnership program evaluation: Overview of the first two years. *Peabody Journal of Education, 83*(4), 486-508.

Yoon, K.S., Duncan, T., Silvia W.L, Scarloss, B., & Shapley, K.L. (2007). *Reviewing the Evidence on how teacher Professional Development Affects Student Achievement*, Washington, D.C.: National Center for Educational Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. Retrieved August 11, 2012 at http://ies.ed.gove/ncee/edlabs/projects/project.asp?projectID=70&productID=31.

Zimmermann, G., Carter, J., Kanold, T. & Toncheff, M. (2012). *Common Core Mathematics in a PLC at work: High School.* T. Kanold (Ed.). Bloomington, IN: Solution Tree Press.