EXAMINING THE EVOLUTION OF A UNIVERSITY SUMMER CAMPUS PROGRAM FOR MATHEMATICS TEACHERS

A Dissertation Proposal Presented to the

Faculty of the College of Education

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

by

Susan Vincent Troutman

December 2015

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Abstract

During the last century, concerns about America's economy, national security, and social justice have swayed citizens, educators, and politicians to recommend changes in mathematics education. School leaders and policy makers realized that if the recommended changes in the mathematics curriculum were to be successful, mathematics teachers would need high-quality professional development to transform their teaching in order to provide all of their students with opportunities and support necessary to learn significant mathematics with depth and understanding.

The University School Mathematics Project (USMP) was established in 1987 as a bridge between the mathematics research community and mathematics teachers. While this specific goal of the program has remained constant, the professional development provided during the USMP Summer Campus Program (USMP SCP) for K-12 mathematics teachers has undergone significant changes in response to a variety of social and political factors.

The purpose of this study was to investigate the evolution of the USMP SCP, examine the factors that impacted the evolution of the program, and identify components of the program that contributed to its sustainability. A qualitative research design that incorporated components of case study, narrative, and historical research was utilized for this study. Participants of this study included a selection of USMP SCP administrators, master teachers who provided instruction during the USMP SCP, and participants of the USMP SCP. Surveys and interviews with these different populations, who had varying

perspectives on the USMP SCP, and the examination of archived data provided a holistic understanding of the USMP SCP. Content analysis was used to analyze the written responses given on descriptive surveys, oral statements given during the focus group and interviews, and relevant archived data collected.

Data collected for this study suggested that the evolution of the USMP SCP was impacted by financial support, changes in the teaching force, curriculum standards, technology, accountability, and equity. By responding to these factors impacting mathematics education, the USMP SCP has evolved and continues to be an enduring source of professional development for mathematics teachers. Several aspects of the USMP SCP were found to contribute to its sustainability. These components include the faculty and staff, collaboration and adaptability, high-quality professional development, and communities of practice. The findings from this study will contribute to the body of research on professional learning for K-12 mathematics teachers.

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Chapter I

Introduction

> *Perceptions of the nature and role of mathematics held by our society have a major influence on the development of school mathematics curriculum, instruction, and research. The understanding of different conceptions of mathematics is as important to the development and successful implementation of programs in school mathematics as it is to the conduct and interpretation of research studies.* (Dossey, 1992, p. 39)

Since "mathematics teaching takes place in societal institutions under the influence of economic, political, ideological, and organizational forces" (Niss, 2007, p. 1295), social and political factors impact the mathematics education of students and teachers. During the last century, concerns about America's economy, national security, and social justice have swayed citizens, educators, and politicians to recommend changes in mathematics education. These changes were based on the belief that mathematics education empowers citizens to contribute to the socio-economic and technological development of society; contribute to the cultural, political, and ideological maintenance and development of society; and attain the prerequisites that will help them cope with their life as citizens (Niss, 2007). School leaders and policy makers realized that if the recommended changes in the mathematics curriculum were to be successful, mathematics teachers would need high-quality professional development to transform their teaching in order to provide all of their students with opportunities

and support necessary to learn significant mathematics with depth and understanding.

With the push for systemic reform in education, many advocated the formation of university/school collaborations to provide professional development for teachers. Recognizing that institutions of higher education play a key role in the preparation and professional development of mathematics teachers, programs such as the Math Science Partnerships, which are supported by the National Science Foundation (NSF) and the United States Department of Education, and NSF's Robert Noyce Teacher Scholarship Program have fostered new partnerships and extended existing university/school collaborations (Conference Board of the Mathematical Sciences [CBMS], 2012).

However, collaborations between K-12 teachers and university-based educators have frequently been problematic. The "historical meanings of 'research' (as critical, exploitive, and disempowering for teachers) and 'professional development' (as mandated, decontextualized, and often irrelevant to teachers' concerns and interests) animate these problematic relationships" (Carlone & Webb, 2006, pp. 545-546). This historical idea that information and knowledge flow from universities to teachers sustains a hierarchical model for university/school collaboration. This model suggests that the university educators who possess knowledge at the higher parts of the hierarchy will impart that knowledge to teachers who are at the lower parts of the hierarchy. In this hierarchical model for professional development where the knowledge of teachers

is considered to be less valuable than the knowledge of university educators, teachers often feel disempowered (Carlone & Webb, 2006).

Establishing and sustaining university/school collaborations that support educational reform require communication within and across groups. In order for university/school collaborations to be successful, there must be a shared set of goals and respect for different perspectives (Edens, Shirley, & Toner, 2012; Weiss, Heck, Pasley, Gordon, & Kannapel, 2010). It is essential that what is accomplished in the collaboration "be greater than what any of the members of the partnership could have accomplished individually. And all the players must have a significant commitment to using their expertise along with that of the others to enhance both teaching and learning" (Richmond, 1996, p. 217).

A combination of both social and political factors has influenced university/school collaborations and the teaching and learning of mathematics. A historical look at these social and political factors will lead to a better understanding of mathematics education and professional development which are both important in overcoming the significant challenges America faces in providing high-quality mathematics education to all of its students.

Concern about the mathematics education of all American students is abundant and on the increase. According to the National Research Council (2001), "citizens who cannot reason mathematically are cut off from the realms of human endeavor. Innumeracy deprives them not only of opportunity but also of competence in everyday tasks" (p. 1). However, since 2003, the average United States mathematics literacy score has consistently been lower than the average scores of 34 Organization for Economic

Cooperation and Development countries (Aud et al., 2012). As concern grows about student achievement in mathematics, public education in America is "leaving a period in which questions of practice and its improvement were essentially pushed into the classroom, where doors were shut and teachers were left to develop their own ideas and practices" (Elmore, 2002, p. 28). The personal, occupational, and educational demands of the twenty-first century require that all citizens attain a level of mathematical proficiency that in the past was required of only a few. However, gaps in the mathematical proficiency levels that exist between the economically advantaged and disadvantaged and among the diverse populations of the United States impede the attainment of these goals (Condron, 2011; RAND Mathematics Study Panel & Ball, 2003).

The National Assessment of Educational Progress' (NAEP) reports provide a picture of the extent to which student performance has changed over time and present information about achievement levels by race/ethnicity and grade. This mathematics assessment measures students' abilities in five areas: number sense, properties, and operations; measurement; geometry and spatial sense; data analysis, statistics and probability; and algebra and functions. There are three achievement levels used to describe student achievement on NAEP. The Basic achievement level is defined as partial mastery of the prerequisite knowledge and skills that are necessary for proficient work at each grade. The Proficient level is defined as solid academic performance where students have demonstrated competency on challenging subject matter which includes applying that knowledge to real-world situations. The Advanced level is defined as superior performance. The National Assessment Governing Board believes that all students should reach the Proficient level (National Center for Education Statistics, 2015).

In 2015, the NAEP mathematics achievement-level results indicated that for the selected racial and ethnic groups, the percentage of fourth-grade students at or above the Proficient level were 51% of White students, 19% of Black students, 26% of Hispanic students, and 62% of Asian/Pacific Islander students. The percentages of eighth graders scoring at or above the Proficient level for mathematics achievement followed a similar pattern. Results of the 2015 NAEP mathematics achievement assessment for eighth grade indicated that for the selected racial and ethnic groups, the percentage of students at or above the Proficient level were 43% of White students, 13% of Black students, 19% of Hispanic students, and 59% of Asian/Pacific Islander students (National Center for Education Statistics, 2015). Although the percentages of racial/ethnic groups for twelfth-grade students performing at or above the Proficient level were similar to patterns for the fourth- and eighth-grade students, the actual percentages were lower. Results of the 2013 NAEP mathematics achievement assessment for twelfth grade indicated that for the selected racial and ethnic groups, the percentage of students at or above the Proficient level were 33% of White students, 7% of Black students, 12% of Hispanic students, and 47% of Asian/Pacific Islander students (National Center for Education Statistics, 2014).

The United States is "at risk of becoming a divided nation in which knowledge of mathematics supports a productive, technologically powerful elite while a dependent, semiliterate majority, disproportionately Hispanic and Black, find economic and political power beyond reach" (National Research Council, 1989, p. 14). Many students, especially those of color and those from less-advantaged backgrounds, are disproportionately instructed by teachers who are insufficiently prepared to teach mathematics (RAND Mathematics Study Panel & Ball, 2003). Educational leaders and

policy makers realize the importance of teacher professional development as a method to close these achievement gaps.

As the measurement and publication of evidence about student performance become part of public discourse about schools, expectations for student performance increase, and it becomes obvious that there is a need for new knowledge about teaching and learning, new structures in which teachers and administrators can adapt and refine new ideas and practices, and new sources for making connections between student performance and instruction (Elmore, 2002). *Teaching at Risk: A Call to Action*, a report released by The Teaching Commission (TTC) in 2004, acknowledged that assisting teachers to succeed and enabling students to learn are investments in human potential (TTC, 2004). In March, 2010, the United States Department of Education (USDE) released *A Blueprint for Reform: The Reauthorization of the Elementary and Secondary Education Act*. One area that the blueprint focused on was improving teacher and principal effectiveness to ensure that every classroom has a great teacher and every school has a great leader. Recognizing that a good education is crucial for citizens to contribute to a democracy and to thrive in a global economy, support was promised for states, districts, school leaders, and teachers to implement a more comprehensive education through high-quality professional development and evidence-based instructional models (USDE, 2010).

Statement of the Problem

Transforming teaching will require more than high-quality recruiting and initial education; it will involve the effective development of teachers through different forms of professional development (Schleicher, 2011). Developing the knowledge that is required

to address the learning challenges of students is essential in order to provide teachers with the tools they need to provide equitable education for all students. Effective teachers must know and deeply understand the mathematics they are teaching and have frequent and ample opportunities to reflect and seek improvement through professional development that will enhance and refresh their knowledge (CBMS, 2012; Killion, 2002; National Council of Teachers of Mathematics, 2000).

In practice, professional development describes a wide assortment of activities ranging from highly targeted work with teachers involving "specific curricula and teaching practices through short 'hit-and-run' workshops designed to familiarize teachers and administrators with new ideas or new rules and requirement, to off-site courses and workshops designed to provide content and academic credit for teachers and administrators" (Elmore, 2002, p. 6). During the last century, professional development for mathematics teachers has changed dramatically. Education has come to play an important role in public initiatives that support the building of human capital and a knowledgeable workforce. Education is no longer concerned with only what transpires "in classrooms and schools, but increasingly about rules and regulations promulgated in state capitals and the federal government designed to improve student academic performance and social development as well as the management and operation of the schools they attend" (Sykes, Schneider, & Ford, 2009, p. 1).

Due to changes in local, state, and national educational policies, university summer campus programs providing professional development to teachers have had to adapt to these changes in order to provide relevant instruction to their participants. Although the need for professional development has been documented, there is a gap in

knowledge on how university mathematics professional development programs evolve to address the social and political demands of the nation. Understanding that universities across America are presently "enacting an agenda of civic engagement with their neighboring communities, and that the nature of university-school-community relationships has been characterized by collaboration at best and exploitation at worst, further investigation of the nature of university-school-community relationships is warranted" (Miller & Hafner, 2008, p. 67). According to Miller and Hafner, there is a gap in the empirical literature concerning these partnerships that can be addressed by understanding the planning, implementation, and evaluation of these partnerships.

Purpose of the Study

The purpose of this study was to investigate the evolution of a university summer campus program for mathematics teachers that was designed to form university/school partnerships. This research involved taking a historical look at the factors, including social and political factors, which influenced changes in mathematics education during the last 125 years and identifying characteristics of effective professional development and components that contribute to the sustainability of university summer campus programs. This study focused on a specific university department referred to by the fictitious name of University School Mathematics Project (USMP) and its summer campus program (USMP SCP) for K-12 mathematics teachers in hopes that this research would provide relevant information for university/school partnerships and other entities providing professional development for mathematics teachers. The university associated with this program is a private research university located in a large metropolitan area in the south-central region of the United States.

The USMP was established with an NSF grant in 1987 to provide a bridge between the mathematics research community and mathematics teachers. The mission of the USMP is to assist school administrators and mathematics teachers in better understanding the nature and importance of mathematics and providing effective teaching and assessing of mathematics in order to equip students for success in the mathematics they encounter in today's society. Since its establishment in 1987, the USMP "has evolved over time, transcending its initial goal, and now serving as a nationally recognized K-12 mathematics education center with a documented ability to improve teacher knowledge and student learning" (Cruz et al., 2013, p. 48).

The cornerstone of the USMP's work with the mathematics community is its summer campus program. The USMP SCP was selected for this study because, since its founding in 1987, it has undergone significant changes. Initially designed as a six-week program that focused on developing content knowledge of 48 secondary mathematics teachers, the USMP SCP has evolved into a three-week program with an academic-year component that serves 80 K-12 mathematics teachers. The current USMP SCP focuses on developing the mathematical and pedagogical knowledge of teachers by including various components of contemporary mathematics education such as mathematics content outlined on state and national standards, classroom instruction, formative and summative assessments, and equitable teaching practices (Cruz et al., 2013). The recognition of the USMP SCP as a model program by the National Staff Development Council and other organizations, the frequent replication of the USMP SCP, and "its tenure provide evidence of the success and value of the University School Mathematics

Project. . . . While USMP SCP focuses on mathematics, it serves as a model that could be replicated in other content areas" (Killion, 2002, p. 85).

The USMP SCP has been a guiding force in my professional life since I participated in the program in 1988. During that summer, I joined other middle school and high school mathematics teachers for a six-week program focused on enhancing our knowledge of upper-level mathematics. Instruction for our courses was provided by university professors and master teachers. The master teachers had been selected as instructors for the USMP SCP based on their identification by local school district mathematics leaders and university faculty as knowledgeable, experienced, and exemplary classroom mathematics teachers. The USMP SCP provided opportunities for me to collaborate with other middle school teachers to solve challenging mathematics problems which strengthened my knowledge of mathematics and boosted my self-efficacy in understanding and teaching higher-level mathematics.

Two years later, the USMP SCP administrators invited me to be one of the master teachers for the USMP SCP. In the role of a master teacher, I was responsible for working with university professors and other master teachers to plan curriculum and lessons and to provide instruction and mentoring for participants during the USMP SCP. It was energizing for me as a master teacher to see how the participating teachers became excited when they were able to put on "student hats" to learn mathematics.

Since 1990, I have continued to be one of the master teachers for the USMP SCP. This role has given me a unique opportunity to observe the many changes that have occurred during the evolution of this program. Although many of the original USMP SCP goals, such as increasing the mathematical knowledge of teachers and promoting

communication and collaboration among and between classroom mathematics teachers and university mathematicians and statisticians, have remained important components of the program; the USMP SCP has undergone modifications to address the needs of mathematics teachers and their students. As a master teacher for a specific grade band, my perspective of the program and its changes was limited. In order to truly understand the evolution of the USMP SCP and its components, multiple perspectives such as the perceptions of administrators, other master teachers, and participants of the program were needed.

This study was a qualitative study that incorporated components of case study, narrative, and historical research in its study of the USMP SCP. While investigating the evolution of the USMP SCP, I strived to understand the different factors, including social and political factors, which impacted this program and to identify components of the program that contributed to the sustainability of this university summer campus program for K-12 mathematics teachers.

This study addressed the changes that have occurred in mathematics education over the last century, results of research studies on the components and effectiveness of professional development programs for mathematics teachers, and the analysis of historical documentation concerning the evolution of the specific university summer campus program in this study. Findings from this study will contribute to research on professional learning for K-12 mathematics teachers and provide significant information concerning the establishment, evolution, and sustainability of university/school collaborations.

Research Questions

Accordingly, during this study I strived to answer the following questions:

1. How did the University School Mathematics Project's Summer Campus Program for K-12 mathematics teachers evolve to meet the demands of mathematics reform?
2. What factors, including social and political factors, have impacted the evolution of the University School Mathematics Project's Summer Campus Program?
3. What components of the University School Mathematics Project's Summer Campus Program have contributed to the sustainability of the university summer campus program for K-12 mathematics teachers?

In order to answer the questions in this study, historical documentation from a variety of sources including archival data was retrieved, descriptive surveys were administered, a focus group was held, and interviews were conducted.

Summary

The views of society and politicians on the nature and role of mathematics and its teaching, accountability and high-stakes testing, and comparisons on international testing have been instrumental in the development of mathematics curriculum, instruction, and research (Dossey, 1992; Niss, 2007). Policy makers recognize that schools are only as good as the teachers and administrators working within them. A critical component for improving education is high-quality professional development which results in improving teachers' knowledge and instructional practice and students' learning outcomes. In order

for mathematics teachers to be effective, it is essential that they develop mathematical and pedagogical content knowledge.

This study includes data collected while investigating the evolution of a university summer campus program for K-12 mathematics teachers to understand how this program evolved to meet the demands of mathematics reform and the factors, including social and political factors, which may have impacted this evolution. Data describing the components of the USMP SCP that contributed to its sustainability are also included.

Chapter II

Literature Review

> *The nation can adopt rigorous standards, set forth a visionary scenario, compile the best research about how students learn, change textbooks and assessment, promote teaching strategies that have been successful with a wide range of students, and change all the other elements involved in systemic reform – but without professional development, school reform and improved achievement for all students will not happen. Unless the classroom teacher understands and is committed to standards-based reform and knows how to make it happen, the dream will not be realized.* (American Federation of Teachers, 2008, p. 2)

According to Usiskin (2010), it is "ironic that the mathematics curriculum is perhaps the most consistent curriculum of all subjects in school (with the possible exception of foreign languages), yet its variations cause disputes that often are acrimonious" (p. 27). Standards for mathematics education have been the focus of controversial debates within social and political arenas. The "type (content, performance, input), target (students – all or differentiated; teachers; schools; districts) and use (improving educational quality, increasing educational opportunity, monitoring, gatekeeping) of the standards, however, have changed over time" (Goertz, 2010, p. 51). Along with these changes in standards comes the recognition that professional development is critical to the successful transformation of schools.

Many of the contemporary practices in mathematics have their roots in educational changes that have occurred in the past. Mathematics education has been influenced by a variety of diverse factors including a "constellation of mathematical,

political, psychological and sociological elements" (Lambdin & Walcott, 2007, p. 4). This literature review includes a historical look at mathematics education, starting just prior to the twentieth century and extending to the present day, and examines the factors which influenced the changes in mathematics curriculum. Results of studies researching the impact and characteristics of professional development programs for mathematics teachers and university/school collaborations are also included in this literature review.

A Historical Look at Mathematics Education

Kilpatrick (2014) noted that "Although mathematics has been taught and learned for millennia, not until the past century or so have the nature and quality of teaching and learning mathematics been studied in any a serious matter" (p. 267). It was not until the late 1800s that scholars began to focus on school mathematics.

Late nineteenth century and early twentieth century. The cornerstone of the nineteenth-century educational system in the United States was the teacher. "Ill-trained, harassed, underpaid, and often immature, it was the teacher who was expected to embody the standard virtues and community values and, at the same time, to mete out stern discipline to the unruly and the dull witted" (Kliebard, 1982, p. 16). By the 1890s, the role of the school had changed from being a visible instrument of a unified community to being an institution conveying the norms for surviving in an industrial society. With this shift in the school's social role came struggles for control of the curriculum (Kliebard, 1982).

Adaptations for a changing society. One of the first major calls for standardization of mathematics curricula was issued in 1894 by the Committee of Ten on Secondary School Studies which was composed of presidents of prominent universities.

This committee declared that radical changes were needed in the teaching of arithmetic. They called for teaching that exercised students' mental activities and recommended that textbooks be subordinate to living teachers. Teachers were encouraged to use concrete forms and heed the facility and correctness in students' work. The committee also recommended the introduction of algebraic expressions and symbols and concrete geometry into grammar schools (National Education Association, 1894/2010).

In 1916, the National Committee on Mathematical Requirements (NCMR) was organized under the auspices of The Mathematical Association of America to give national attention to the reform movement in the teaching of mathematics. This committee agreed that it was essential to understand the aims and purposes of mathematics education to intelligently approach problems dealing with material selections, teaching methods, and views concerning instruction and teacher qualifications and trainings. According to the NCMR (1922):

> The primary purpose of the teaching of mathematics should be to develop those powers of understanding and of analyzing relations of quantity and of space which are necessary to an insight into and control over our environment and to an appreciation of the progress of civilization in its various aspects, and to develop those habits of thought and of action which will make these powers effective in the life of the individual. (p. 9)

While the emphasis of the NCMR's report was on the content and its organization in mathematics courses, the committee strongly highlighted the importance of teachers. Acknowledging that poor teaching was the major reason for the failure of students to learn mathematics, the committee stated that good teachers had succeeded in the past and

would continue to succeed in achieving satisfactory results with the use of traditional material while poor teachers would not be successful even with new and better resources (NCMR, 1922). During this period of time, many Americans had the belief "that 'anybody can teach mathematics' by simply following a textbook and devoting 90 per cent of the time to drill in algebraic manipulation or to reciting the memorized demonstration of a theorem in geometry" (NCMR, 1922, pp. 13-14). The report criticized this view by suggesting that successful mathematics teachers must be highly trained in their subjects.

Influence of reformers. During this time, four interest groups including the humanists, developmentalists, social efficiency educators, and the social meliorists emerged to influence curriculum policies. The humanists exerted their influence to reinterpret and preserve the revered traditions and values of Western culture in spite of the rapid changes to their society. Three different types of reformers rallied against the group of humanists. The first of the reformers were the developmentalists who led the movement to align curriculum with children's natural stages of development. The second group of reformers was the social efficiency educators who wanted priority given to a scientifically created curriculum that would lead to the creation of an efficient, smoothly run society. The last group of reformers was the social meliorists who believed that social change and social justice could be addressed by developing a curriculum that focused on these issues and giving schools the power to create a new social order (Kliebard, 1982; Schoenfeld, 2004; Stanic, 1986). None of the interest groups gained complete control and "what became of the American curriculum was not the result of any decisive victory by

any of the contending groups, but a loose, largely unarticulated, and not very tidy compromise" (Kliebard, 1982, p. 23).

By the 1930s, mathematics educators in the United States were faced with a crisis that had developed "in the context of major social changes arising from intense urbanization, industrialization, and immigration around the turn of the century; America's involvement in World War I; and the Great Depression" (Stanic, 1986, p. 190). The school systems became overwhelmed by escalating student populations as students were being kept in secondary schools to delay their entry into the job market. At a time when economic growth was based on workers in assembly lines performing repetitive tasks, "it made sense to teach only a few future managers, engineers, and public leaders to think and to prepare the majority of students for a future of following directions" (Resnick, 1995, p. 79).

Dewey, an educator and a philosopher, was concerned with these traditional classrooms where he saw "passivity, rigidity, and uniformity locked into place. Teachers, the dispensers of knowledge, had their places at the front; students, the receivers of knowledge, had their places in the rear" (Newman, 1990, p. 172). He condemned the parallels between these traditional classrooms and factories and called for a progressive educational system where students were actively learning what interested them as well as what was significant to society. The progressives encouraged schools to develop child-centered classrooms by incorporating innovative methods such as activity-based projects that would teach social lessons as well as academic content (Cuban, 1990; Newman, 1990). Kilpatrick, one of Dewey's protégés, believed that the restriction of education to mainly practical skills justified the relaxed pace of the student-centered learning

advocated by progressivists. He rejected the idea that mathematics would promote mental discipline and stated that "nothing in mathematics should be taught unless its probable value could be shown, and recommended the traditional high school mathematics curriculum for only a few" (Klein, 2003, p. 179).

By accepting the progressivists' view of education, public schools focused on meeting the personal and social needs of their students instead of concentrating on teaching basic skills and academic principles to their students. Critics opposing this progressive theory of education became vocal in the 1940s when army recruits were found to be so deficient in mathematics that in order to handle jobs such as basic bookkeeping and operating guns, the recruits first had be taught the basic skills of arithmetic required for those jobs. Admiral Nimitz found that even prospective officer candidates and volunteers for the navy were lacking in mathematical skills. Although there was public outrage over the demonstrated mathematics deficiencies, Schoenfeld (2004) noted that there were very few changes made to curriculum.

Mid-twentieth century. During the first half of the twentieth century, student enrollment decreased in advanced high school mathematics courses. Many blamed progressive education for focusing on life adjustment programs instead of focusing on academic content (Klein, 2003). However, historical events of the 1950s directed the nation's attention to mathematics education.

Response to Sputnik. The United States was caught off guard in October 1957 by the Soviet Union's successful launching of Sputnik. Viewed as a threat to our national security, science and technology leadership, and political freedom, Sputnik's launching prompted the American scientific community to develop new curriculum for mathematics

and science. Embedded in this "new math" was starkly different content including modular arithmetic, set theory, and symbolic logic. Reformers soon found out that the successful implementation of this new curriculum relied on it being made accessible to all stakeholders. Teachers felt inadequate to present material they had not been prepared to implement, and parents felt incompetent to help their children and did not recognize the significance of the new curriculum (Bybee, 1997; Schoenfeld, 2004).

A critical shortage of mathematics teachers accompanied this revolutionary new curriculum. Programs to prepare teachers were described as content driven, while teacher inservice programs were characterized "as 'quick fix' remedies. Teachers, as agents responsible for carrying out a fragmented national agenda to raise the level of student performance, had no time to collaborate with colleagues, plan for instruction, or reflect on their practices" (Castle & Aichele, 1994, p. 2). Teachers discovered that they had the unenviable task of trying to learn just enough mathematics to enable them to teach the next lesson.

In addition to implementing new curriculum for academic reform, teachers were faced with social reform challenges and providing expanding educational opportunities for all students. In 1965, the Elementary and Secondary Education Act was enacted to allocate federal funds for educational research and development and to support educational agencies serving underprivileged children (Goodland, 1995; Thomas & Brady, 2005). Programs such as Headstart and Title I were initiated in an attempt to equalize educational opportunities for disadvantaged students. Pressure was also placed on schools and teachers to provide social reforms.

> Courses in marriage and the family, physical fitness, driver's training, sex education, drug prevention, career education, values clarification, and even death education entered the public school curriculum. Schools would prepare youth to create a better society from womb to the tomb. (Hiatt, 1986, para. 8)

As parents, teachers, and students struggled with the social and academic changes in schools, "back to basics" became the new theme of mathematics education in the 1970s. This back-to-basics movement narrowed the mathematics curriculum to focus on computation rather than problem solving (Castle & Aichele, 1994; Newman, 1990; Schoenfeld, 2004). Opponents of the new mathematics curriculum criticized the conceptual and discovery methods of instruction for not addressing the learning styles and capabilities of the diverse population of students. Discouraging reports of poor student achievement motivated the adversaries of new mathematics to claim that the excessively formal and deductively structured components of the new curriculum deviated from the inductive and concrete approaches used in real-world situations (Hill, 1976).

***Growing concern about mathematics curriculum*.** In 1974, the National Advisory Committee on Mathematics Education (NACOME) was formed by the Conference Board of the Mathematical Sciences to analyze the changes in K-12 mathematics education. The NACOME report acknowledged that mathematics scores had declined in the previous ten years. However, the report suggested that this decline was not entirely due to the new mathematics curriculum. The low scores in mathematics were accompanied by declines in scores for all school subject areas which suggested that

explanations for the disheartening scores were based on broader school and societal factors.

Hill (1976) reported that the NACOME committee members found evidence that many principles advocated by the new mathematics curriculum were not found in all schools across America, especially in the elementary schools. Despite efforts to promote an innovative curriculum and update the mathematical competence of teachers, committee members were dismayed by their observations of an increased focus on drills of computational skills in mathematics classrooms. The members of NACOME reported that methods emphasizing rote memory and drill "contribute nothing to a confused child's understanding, retention, or ability to apply specific mathematical knowledge. Furthermore, such instruction has a stultifying effect on student interest in mathematics, in school, and in learning itself" (NACOME, 1975, p. 24). Recognizing that minimum skills should not become the ceiling of mathematics performance for any student, the committee recommended that contemporary mathematics curriculum for all students include the following features. The mathematics curriculum should:

- maintain a logical structure as a framework for mathematics,
- include concrete experiences as an essential component for acquiring abstract ideas,
- provide all students with opportunities to apply mathematics in real-world problems,
- develop familiarity with the uses, formalities, and limitations of symbols in an appropriately balanced manner,

- make calculators available for students to use in mathematics classes no later than at the end of grade 8,
- allow all students to have the opportunity to participate in computer science courses,
- attend to the implementation of the metric system and examine instruction sequences in fractions and decimals, and
- incorporate statistical instructional units throughout the elementary and secondary mathematics curriculum (NACOME, 1975).

Recognizing that "one of the clearest failures of the new mathematics effort was its inability to effectively change the curricular priorities or instructional methods in any broad cross section of American classrooms" (Hill, 1976, p. 445), NACOME committee members realized that successful implementation of recommended changes in instructional methods and resources would not occur unless mathematics teachers were given the opportunity to participate in professional development. The factors suggested by the committee to consider when planning these inservice programs included the conditions under which teachers attend the program, opportunities for teachers to have input in the program, opportunities for teachers to adapt methods or resources to their individual styles of instruction, and opportunities for teachers to share apprehensions and to brainstorm ideas for implementation of recommendations for new mathematics curriculum (NACOME, 1975).

***Development of a national agenda for action*.** By 1980, the National Council of Teachers of Mathematics (NCTM) recognized that it was unwise for the exclusive focus of mathematics curriculum to center on basic skills. Aware of the valid and legitimate

role that public opinion played in determining educational goals, NCTM published *An Agenda for Action* to inform the public of NCTM's beliefs about the direction that should be taken in mathematics education. NCTM's recommendations for school mathematics of the 1980s included:

- focusing on problem solving,
- defining basic skills to include more than computational facility,
- utilizing calculators and computers at all grade levels,
- applying standards of effectiveness and efficiency to mathematics teaching,
- using a wide range of measures to evaluate mathematics programs and student learning,
- requiring all students to study more mathematics and provide a flexible curriculum with a variety of options to accommodate the diverse needs of all learners,
- demanding a high level of professionalism for mathematics teachers, and
- raising public support for instruction in mathematics to a level proportionate to the significance of mathematics understanding to individuals and society (NCTM, 1980).

In *An Agenda for Action,* NCTM reported that due to the shortage of qualified teachers many mathematics classrooms were led by teachers who did not have the recommended subject-matter qualifications for teaching mathematics. According to NCTM, school administrators were obliged to inform parents of this situation and to provide support for teachers as they made up their deficiencies in mathematics. Teachers were also warned

that a new level of motivation and commitment would be required to remain professional as "the continuing appearance of new concepts and theories in mathematics, in the applications of mathematics, and in the teaching-learning process will affect both curriculum and instruction in school mathematics" (NCTM, 1980, p. 24).

Late twentieth century. Towards the latter part of the twentieth century, many recognized the decline in the quality of mathematics education in America. Concern about the economic ramifications of inadequately prepared workers in a global market alerted politicians and educators of the need for reform.

Concern about a nation at risk. In the 1980s, Americans faced an economic crisis while the Japanese and other Asian economies soared. Concerned about the ability of the American educational system to prepare students for a competitive workforce, Bell, the United States Secretary of Education, appointed a commission to study issues in education (Schoenfeld, 2004). *A Nation at Risk* issued by The National Commission on Excellence in Education (NCEE) reported in 1983 that:

> Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. . . . The educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. . . . If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have even squandered the gains in student achievement made in the wake of the Sputnik challenge. Moreover, we have dismantled essential

> support systems which helped make those gains possible. We have, in effect, been committing an act of unthinking, unilateral educational disarmament. (p. 112)

This report was another wake-up call for Americans to commit themselves to reforming the educational system as an investment in keeping America's position in the world secure.

Among the educational dimensions endangering America's slim competitive edge in world markets were the functional illiteracy of approximately 23 million American adults, the dismal results of the American students' achievement on standardized tests and international comparison assessments, the increase in remedial mathematics courses taught in public colleges, and the complaints by business and military leaders that millions of dollars were being spent on remedial education and training programs to teach basic skills in computation, writing, reading, and spelling.

While concern was growing that this new generation of Americans was technologically and scientifically illiterate, Slaughter, a former Director of the National Science Foundation (NSF) cautioned of "a growing chasm between a small scientific and technological elite and a citizenry ill-informed, indeed uninformed, on issues with a science component" (NCEE, 1983, p. 116). The commission also reported on the need to improve teacher preparation programs and the existence of a severe shortage of teachers in key fields.

In order to achieve the goals of high-quality schools and equity, the commission gave several recommendations based on the beliefs that every person can learn, that all have an innate desire to learn which can be supported, that all students can acquire a quality high school education, and that life-long learning would provide the population

with the skills necessary for new careers and citizenship. Their recommendations focused on strengthening state and local requirements for high school graduation; adopting higher expectations and more rigorous and measureable standards by schools, colleges, and universities; requiring more time be dedicated to learning the New Basics, which included English, mathematics, science, social studies, and computer science; improving teacher preparation and making teaching more rewarding and respectable; and encouraging American citizens to provide the financial support and stability needed to achieve the proposed reforms and to hold elected officials and educators accountable for providing the guidance required to accomplish these reforms (NCEE, 1983).

After the publication of *A Nation at Risk*, there was debate about whether the report was really a true picture of academic standards or merely a manufactured crisis supported by questionable techniques that was meant to undermine public education and divert attention from the actual problems facing education in America. Critics of the report complained that not enough attention was given to the social and economic issues impacting educational outcomes (Berliner & Biddle, 1995; Ravitch, 2010).

Whether *A Nation at Risk* provided accurate details or a distorted picture of education in America, it focused attention on educational reform. Following the release of *A Nation at Risk*, state education agencies began to wield power on classroom instruction by developing and implementing ambitious curriculums and assessments. *Action in the States* reported that 44 states had increased graduation requirements; 30 states had created new regulations governing outcomes for learning, content for curriculum, and frameworks; 45 states had strengthened requirements for teacher certification and evaluation; and 27 states had employed initiatives to increase

instructional time (Schwartz & Robinson, 2000). Although these reform efforts were supported by local school districts and states, many policy makers were frustrated by the poor achievement scores of students (Vinovskis, 1999).

Reformers questioned whether the political power of national or state agencies could actually steer instruction and learning in thousands of classrooms led mainly by teachers lacking deep knowledge of their academic subjects (Cohen & Hill, 2000). Recognizing that the quality of education for American students in mathematics and science was dependent on competent teachers, NSF initiated its Teacher Enhancement Program in 1984. Between 1984 and 1989, more than 600 grants were awarded to mathematicians, scientists, and educators through the Teacher Enhancement Program. These grants were designed to "enhance teacher effectiveness while serving as prototypes for other in-service projects. The program recognized the need for elementary and secondary science and mathematics teachers to continue their professional development and to renew their professional commitments" (Abt Associates & NSF, 1993, p. 10).

Developing national standards. NCTM also responded to concerns about deficiencies in teacher knowledge by issuing the Professional Development Programs for Teachers of Mathematics in 1985. This position statement noted that:

> Because mathematics and education are disciplines that grow and change, teachers cannot depend on what they learned as undergraduates to carry them through their entire careers. Findings of research continually increase our understanding of teaching and learning. Further, social and technological changes increase the average citizen's need to understand and use mathematics. These

> forces demand reconsideration of the content and methods of mathematics instruction. (Johnson et al., 1986, p. 1)

Contrary to the commonly held belief that a good teacher could teach anything, this position statement indicated that teachers needed ongoing professional development that incorporated experiences to increase their pedagogical and content knowledge and to become familiar with the multiple resources available for teaching mathematics (Johnson et al., 1986).

Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) was prepared in response to calls for reform in mathematics teaching and learning. The tasks assigned to the authors of this document included creating a coherent vision outlining mathematical literacy both for a world that depended on calculators and computers to preform mathematical procedures and for a world where mathematics was utilized in diverse fields. They were also tasked with creating standards that would guide the revision of curriculum and evaluation for school mathematics. NCTM (1989) acknowledged that in order to meet the economic needs of the industrial age, education needed to include new social goals which included "mathematically literate workers, lifelong learning, opportunity for all, and an informed electorate" (p. 3). To address these social goals, five general goals were listed for students: learn to value mathematics, gain confidence in their mathematical ability, become mathematical problem solvers, learn to communicate mathematically, and learn to reason mathematically (NCTM, 1989).

By advocating student-centered lessons and discovery learning, the common themes of progressive education were emphasized in NCTM's *Curriculum and Evaluation Standards for School Mathematics*. Justifications for these changes followed

the themes of social justice and the demands of industry and business (Klein, 2007). With threats of a polarized society where intellectual elites controlled scientific and economic developments, NCTM (1989) stressed that all students should have the opportunity to learn mathematics. According to Klein (2007), "the confluence of social justice themes, attendance to the needs of business and the promise of conceptual understanding of mathematics for all students gave the NCTM's agenda the momentum it needed" (p. 24).

NCTM continued its commitment to guiding reform in mathematics education by releasing *Professional Standards for Teaching Mathematics* in 1991. To promote the development of mathematical power in all students, NCTM (1991) stated that elementary and secondary mathematics teachers needed to be more proficient in choosing tasks that would engage students' intellect and interests, providing opportunities that would deepen students' understanding of mathematics and its applications, managing classroom discussions to promote the exploration and development of mathematical ideas, searching and encouraging students to search for connections between previous and developing knowledge, and guiding students as they work individually, in small groups, or with the entire class. The authors maintained that teachers had significant roles in changing how mathematics was taught and learned in schools and that those changes depended on teachers receiving appropriate resources and long-term support (NCTM, 1991).

In 1992, NCTM began development of *Assessment Standards for School Mathematics* as a supplement for the *Curriculum and Evaluation Standards for School Mathematics* and the *Professional Standards for Teaching Mathematics.* According to NCTM (1995), the purposes of assessment were to monitor student progress, make instructional decisions, evaluate student achievement, and evaluate programs.

As background for the *Assessment Standards for School Mathematics,* NCTM (1995) indicated that previous attempts to assess student performance often "underestimated the mathematical capability of most students and perpetuated costly myths about students' ability and effort. Too often, tests designed for other purposes have been used as filters that deny underrepresented groups access to the further study of mathematics" (NCTM, 1995, p. 1). Recognizing America's multicultural society, NCTM suggested that equitable assessment practices would assist in promoting equity in the educational system.

NCTM stated that assessment practices had to change in order to remain consistent with reforms in curriculum and instruction. Their goal for producing this document was to provide assessment strategies that would reflect the reform vision that NCTM promoted for school mathematics. Their vision, grounded on the notion that all students are able to learn mathematics, included expectations for students' knowledge of mathematics and their ability to apply that knowledge, the methods by which students learn mathematics, and the assessment of student progress (NCTM, 1995).

According to Wilson and Kenney (2003), research evidence supported NCTM's assessment standards. However, Barton (1999) cautioned against placing too much of an emphasis on exceedingly structured assessment systems and not focusing on teachers as professionals. "Merely setting high standards and developing a new assessment system will not ensure changes in teacher behavior or student performance unless professional development activities and capacity building at the school level are given equal priority" (Winfield & Woodard, 1994, p. 8).

In order to promote coordinated improvements in America's educational system, Congress passed the Goals 2000: Educate America Act in 1994. However due to concerns about the extent of the federal government's involvement in educational policy, it was amended to reduce the requirements necessary for states to receive funding provided by Goals 2000 (United States General Accounting Office [USGAO], 1998). This audacious legislation provided "national direction and leadership in a highly decentralized education system" (Schwartz & Robinson, 2000, p. 174). It proposed the use of federal funds to influence educational reforms at the state level and created new national structures to lead states in the direction of a national strategy. These funds supported reform efforts that focused on improving local schools, improving the education of preservice teachers, and providing professional development. Many believed that this funding allowed states to accelerate the promotion and achievement of educational reforms (Schwartz & Robinson, 2000; USGAO, 1998).

NSF also provided funds to promote educational reform through Statewide Systemic Initiatives, Urban Systemic Initiatives, and Rural Systemic Initiatives. In 1996, NSF elaborated on what it believed constituted effective, standards-based education with the following list of assertions:

- "All children can learn by using and manipulating scientific and mathematical ideas that are meaningful and relate to real-world situations and to real problems.
- Mathematics and science are learned by doing rather than by passive methods of learning such as watching a teacher work at the chalkboard. Inquiry-based learning and hands-on learning more effectively engage students than lectures.

- The use and manipulation of scientific and mathematical ideas benefits from a variety of contributing perspectives and is, therefore, enhanced by cooperative problem solving.
- Technology can make learning easier, more comprehensive, and more lasting.
- This view of learning is reflected in the professional standards of the National Council of Teachers of Mathematics, the American Association for the Advancement of Science, and the National Research Council of the National Academy of Sciences." (Klein, 2003, p. 194)

Although NSF supported progressive education and the standards documented by NCTM, many criticized this view of education. Critics complained that students were encouraged to create their own algorithms for arithmetic instead of using the standard algorithms for basic mathematical operations. They worried that calculator use was excessive and that discovery learning was inefficient. Journalists began to portray these disagreements between those who favored basic skills and those who preferred conceptual understanding of mathematics as the math wars (Klein, 2003). As constructive changes were proposed for America's mathematics curriculum and attacks on reform efforts increased, Riley, the United States Secretary of Education under President Clinton, called for a cease-fire in the math wars (Reys, Robinson, Sconiers, & Mark, 1999; Riley, 1998). Understanding that many educators disagreed on teaching methods and curriculum content, he advocated the use of respectful and constructive discourse. He was hopeful that those interested in education would "have a 'cease-fire' in this war and instead harness the energies employed on these battles for a crusade for excellence in mathematics for every American student" (Riley, 1998, p. 488).

This focus on increasing mathematics achievement for American students was again brought to the nation's attention with the release of results of the Third International Mathematics and Science Study (TIMSS). When comparing the student performance, curriculum, and teaching of up to forty nations, "the United States was the only county in TIMSS whose students dropped from above-average performance in mathematics in the fourth grade to below-average performance in mathematics in the eighth grade" (Riley, 1998, p. 489). According to Franke, Kazemi, and Battey (2007), the TIMSS report indicated that mathematics instruction in the United States was inconsistent with current reform ideas. The report noted that American students were not provided sufficient opportunities to reason about mathematical concepts, discuss connections among mathematical ideas, and develop mathematical understanding.

Twenty-first century. As America entered the twenty-first century, there was a focus on preparing students to meet the challenges of the new century. According to Trilling and Fadel (2009), "though many of the skills needed in centuries past, such as critical thinking and problem solving, are even more relevant today, how these skills are *learned* and *practiced* in everyday life in the twenty-first century is rapidly shifting" (pp. xxiii-xxiv). Reports of students graduating from high schools and universities while lacking basic skills emphasized the need for mathematics reform.

***A vision with high expectations*.** NCTM (2000) attempted to address these issues with the release of *Principles and Standards for School Mathematics*. In this document, NCTM described a vision for twenty-first-century mathematics classrooms that was highly ambitious. While acknowledging that the mathematics education at that time could be improved, NCTM affirmed that standards were key components in that process of

improvement. The goals of the *Principles and Standards for School Mathematics* were to establish comprehensive and coherent objectives for all K-12 mathematics students that would guide curricular, teaching, and assessment efforts; to provide a resource for teachers, educational leaders, and politicians to utilize as they examine and improve instructional programs in mathematics; to direct the development of curriculum frameworks, instructional resources, and assessments; and to encourage dialogues at the local, state, and national levels on the best strategies to assist students in developing a profound understanding of mathematics. NCTM identified equity, curriculum, teaching, learning, assessment, and technology as the principles for school mathematics. NCTM had high expectations that these principles would guide educators in their endeavor to improve mathematics education (NCTM, 2000).

As the United States entered the twenty-first century, many realized that the needs of all students were not being met with the current educational programs. Although billions of dollars had been spent on educational programs, academic achievement gaps still persisted. To address these growing concerns, the Elementary and Secondary Act was reauthorized and renamed as the No Child Left Behind Act (NCLB) of 2001. This "landmark education policy reflected unprecedented and bipartisan commitment to providing a quality education to all American students, regardless of racial, ethnic, or socioeconomic background" (Thomas & Brady, 2005, p. 55). With the focus on helping disadvantaged students attain academic proficiency, NCLB reflected the initial intent of the Elementary and Secondary Act.

The educational blueprint for NCLB was intended to increase accountability for student performance, focus on research-based programs that had proven to be effective,

provide flexibility to states and school districts, and empower parents. The priorities in this blueprint were improving disadvantaged students' academic performance, enhancing teacher quality, increasing the English fluency of limited English proficient students to English fluency, encouraging informed parental choice, promoting school safety for the twenty-first century, boosting the funding for Impact Aid, and urging accountability. This blueprint was proposed so that in the United States no child would be left behind (Bush, 2001).

Historically, many students considered to be at risk were taught by inexperienced and inept teachers. To address this problem, one of NCLB's requirements was that every student have access to a highly-qualified teacher who had a bachelor's degree, state certification or licensure, and competency in the discipline taught (Darling-Hammond, 2010; Nelson, Palonsky, & McCarthy, 2010; Tate & Rousseau, 2007). NCLB also required accountability measures. However, these measures did not give attention to connecting the instructional core to professional development, pedagogy, and assessments given in the classroom (Confrey & Maloney, 2011).

Critics of NCLB believed that this law was more harmful than it was beneficial for American schools. "NCLB's test-and-punish approach to school reform relies on limited, one-size-fits-all tools that reduce education to little more than test prep. It produces unfair decisions and requires unproven, often irrational 'solutions' to complex problems" (FairTest, 2008, para. 1). According to Au (2011), findings of empirical research indicated a narrowing of instructional curriculum that was due to the pressure of NCLB accountability measures leading teachers, at varying degrees, to shape the content of their curriculum to match the content of the high-stakes tests.

In an effort to create a national set of standards for mathematics and English language arts that would prepare students for college, career, and life, the Council of Chief State School Officers and the National Governors Association Center for Best Practices developed the Common Core State Standards (CCSS), which were released in 2010. The focus of the CCSS was on what students should learn at each grade level and not on pedagogy. CCSS offered shared expectations, focus on the curriculum, efficiency, and quality of assessments (Porter, McMaken, Hwang, & Yang, 2011).

Every state in America currently has standards for core subjects in elementary and secondary schools and assessment systems that measure the progress of students towards the standards in mathematics and reading/language arts for students in grades 3-8 and again in high school. However, many believe that existing federal accountability requirements have lowered standards such that students are not being sufficiently prepared to be college and career ready (USDE, 2013).

Crisis in STEM fields. While concern grows about high-stakes accountability and curriculum, troubling signs are pointing to a growing concern that an insufficient number of students, teachers, and professionals are being prepared in science, technology, engineering and mathematics (STEM) fields (Kuenzi, 2008; Members of the 2005 "Rising Above the Gathering Storm" Committee, 2010). Unparalleled international "demand and competition for STEM talent and intellectual capital have catapulted STEM education, research, and innovation to the top of our nation's agenda" (Marshall, 2010, p. 49). During the launching of the Educate to Innovate campaign in November 2009, President Obama spoke of strengthening the role of the United States as the world's engine for scientific breakthroughs and technological advances and emphasized that

improvements in STEM education should be a national priority (President's Council of Advisors on Science and Technology [PCAST], 2010).

There were also troubling signs that, overall, students in the United States should be doing better in mathematics and science. Sawyer reported on *ABC World News Tonight* in December 2010 that "We have a wake-up call now about America's kids. . . . Today, the new international reading, math, and science scores were released, and Chinese students left American teens in the dust in all three categories" (Zhou, 2012, p. 56). Sawyer was referring to results from the most recent Programme for International Student Assessment (PISA) where tenth graders in the United States came in 17th out of 30 countries (McNally, 2012). Discussing the significance of the scores, Duncan, the United States Secretary of Education under President Obama, called it "a modern day Sputnik moment to catch up" (Zhou, 2012, p. 56).

President Obama emphasized the value of STEM education by commenting that during the next decade the United States needed to move its students in science and math from the middle to the highest level of achievement. Understanding that teachers with deep content knowledge and mastery of pedagogical skills were essential factors in improving STEM education, the federal government set a goal of ensuring the recruitment, preparation, and induction support of at least 100,000 new STEM middle and high school teachers during the decade from 2010 to 2020 (PCAST, 2010).

While traditional teacher preparation programs were criticized as being low-quality programs that failed to adequately prepare teachers, Levine, president of the Woodrow Wilson foundation, said "Anyone can throw bricks. The question is: Can you improve it?" (Robelen, 2012, p. 4). Woodrow Wilson foundation officials encouraged

universities and their partners to devise approaches that would best fit their needs. Compelling evidence found in studies conducted by NSF and the National Commission on Teaching and America's Future demonstrated that "STEM teaching is more effective and student achievement increases when teachers join forces to develop strong professional learning communities in their schools" (Fulton & Britton, 2011, p. 4).

Research also suggested that many teachers in the STEM fields were not certified in those subjects and did not major in a related field in college (Committee on Science, Space, and Technology, 2011). Recommendations were made that teachers need access to high-quality, ongoing professional development that will increase their STEM content knowledge as well as pedagogical skills that are essential in creating innovative activities that spark students' curiosity and foster long-term interest in STEM.

Research on Professional Development for Mathematics Teachers

In this era of high-stakes accountability and educational forms, significant changes are needed in classrooms. According to Gulamhussein (2013), research implies that in order to prepare students for higher education and careers in the twenty-first century, the paradigm of instruction currently used by most teachers in their practice will not be adequate. Research has shown that the single most powerful in-school factor influencing student achievement is teacher quality (e.g., Hattie, 2003; Kane & Staiger, 2012; USDE, 2013). In order to empower students with the higher-order thinking skills required to succeed in the twenty-first century, teachers must possess deep content knowledge as well as higher-order instructional skills (Gulamhussein, 2013; Hunt, 2009). "Teacher learning is the linchpin between the present day and the new academic goals" (Gulamhussein, 2013, p. 6).

Results of professional development. While other fields have demonstrated steady improvement fostered by a continually expanding knowledge base, the professional development of teachers has a history of mixed results (Guskey, 2014; Hill, Beisiegel, & Jacob, 2013; National Research Council, 2011). Although millions of hours are invested in professional development, many consider such training to be extremely ineffective (Gulamhussein, 2013; Schmoker, 2006). While professional development is recognized as a critical component in transforming schools and improving academic achievement, the dismal ratings of the usefulness of most professional development activities and teachers' desire for additional professional development on the content they teach, classroom management, and other topics, are indicators of the inadequacy of the professional development framework now in place in most states and communities (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009).

The National Research Council (2011) reported "Weak initial teacher preparation heightens the importance of continuing professional development, but the available research suggests that professional development in STEM, when available, is often short, fragmented, ineffective, and not designed to address the specific need of individual teachers" (pp. 20-21). According to the 2000 National Survey of Science and Mathematics Education which was based on a national probability sample of 5,728 science and mathematics teachers across the United States, an average of less than 20% of the mathematics teachers surveyed reported that their professional development caused them to change their teaching practices (Weiss, Banilower, McMahon, & Smith, 2001).

Although some studies have reported on professional development programs that have not made a significant impact on the mathematical knowledge of teachers, other

studies have reported that professional development has made a positive impact on the mathematical knowledge of teachers. Scher and O'Reilly (2009) examined post-1990 K-12 professional development programs to determine which types of programs were the most effective in improving student academic outcomes in mathematics and science. Their results suggested that intensive professional development interventions for mathematics and science teachers were more effective than the traditional one-shot programs. Professional development that specifically focused only on mathematics or only on science was more likely to have greater impact on student achievement than programs that focused on both mathematics and science. Programs that incorporated both content and pedagogy as part of their professional development had a larger positive impact on student achievement than those that focused on content or pedagogy alone.

In a study that used a national probability sample of 1,027 mathematics and science teachers, Garet, Porter, Desimone, Birman, and Yoon (2001) examined core features of professional development activities that had significant positive effects on the increases in teachers' knowledge and skills and changes in classroom practice. Their results identified several ways to improve professional development. Enhanced teacher knowledge and skills were produced when professional development focused on academic subject matter, allowed teachers to have active learning with hands-on experiences, and became integrated into the daily life of the school. Linking teachers' experiences, aligning with reform efforts, and encouraging professional communication among teachers supported change in teaching practices. The data provided support that the "collective participation of groups of teachers from the same school, subject, or grade level is related both to coherence and active learning opportunities, and which in turn are

related to improvements in teacher knowledge and skill and changes in classroom practice" (Garet et al., 2001, p. 936).

Building on their findings from the national, cross-sectional data, Desimone, Porter, Garet, Yoon, and Birman (2002) conducted a longitudinal study of a purposefully selected sample of mathematics and science teachers from 30 schools. This sample included teachers from elementary schools, middle schools, and high schools in 10 districts in five states. This study focused on examining features of the professional development attended by these teachers and the effects on their teaching practice. The investigation concentrated on three different areas of teaching practice: the use of technology, instructional methods, and assessment practices. By documenting teaching practices before and after professional development, researchers were able to examine the extent to which changes in teaching practice could be predicted by participation in that activity. Although this study did not directly measure the impact of professional development on student achievement, the measures of teaching practice that were used had been linked with improvements in student achievement.

Desimone et al. (2002) reported that the analysis of this study's data, collected from teacher surveys, indicated that "professional development focused on specific teaching practices increased teachers' use of those practices in the classrooms" (p.102). These reported effects were independent of the teachers' previous use of these practices, the subjects they taught, and the school level. The data from the longitudinal study indicated that teachers report professional development as being more effective in changing their classroom practice when it includes active learning opportunities, coherence, and collective participation of teachers from the same grade, department, or

school. Significant benefits were also reported when teachers participated in reform types of professional development that focused on a set of higher order instructional or alternative assessment methods (Desimone et al., 2002).

The development of mathematics teachers is similar to the professional development of all other teachers. However, professional development of mathematics teachers must include a focus on presenting relevant mathematical content in such a manner that it improves student understanding (Castle & Aichele, 1994). Effective professional development opportunities are designed based on the knowledge that "the quality of mathematics teaching and learning depends on what teachers do with their students, and what teachers can do depends on their knowledge of mathematics" (RAND Mathematics Study Panel & Ball, 2003, pp. xv-xvi). Recent research indicates that teacher learning usually occurs when teachers focus on instruction and student outcomes in the specific contexts in which they teach. Learning and applying the information delivered during professional development is more apt to occur when teachers see it as relevant to student learning in their specific school setting (Baker, 2000).

The Rocky Mountain Middle School Math and Science Partnership provided courses that included mathematical experiences relevant to the teachers' classrooms. This project linked teachers from seven Denver-area school districts with faculty from four universities to promote significant growth in the subject-matter content knowledge and pedagogical content knowledge of elementary and middle school science and mathematics teachers. Courses for this program were designed to increase teachers' efficacy and ability as mathematical thinkers, build teachers' abilities to analyze the mathematical thinking of their students, review mathematical concepts to extend

teachers' knowledge past their instructional levels, and develop instructional techniques for inquiry-based learning. Since the researchers lacked data on the participating teachers' subject-matter knowledge and implementation of professional development practices in classrooms, a model was developed to investigate the indirect effect of the professional development on the achievement of students.

Central findings from this study indicated that "teaching mathematics teachers deeper content and how to use an inquiry-based approach to deliver that content does indeed translate into greater student proficiency in mathematics" (McMeeking, Orsi, & Cobb, 2012, p. 175). Studies of this project also found that teachers' levels of outcome efficacy were positively impacted after increasing the level of content-specific knowledge and demonstrating teaching methods appropriate for conveying this knowledge to a diverse group of students (Swackhamer, Koellner, Basile, & Kimbrough, 2009).

Additional research on the effect of professional development on the content knowledge of elementary teachers was conducted by Hill and Ball (2004). The content knowledge for teaching was assessed for teachers attending elementary number and operations institutes of California's Mathematics Professional Development Institutes. Although variations occurred in program content, depth, pedagogy, and quality, most programs included substantial opportunities for teachers to engage in activities designed to enhance their mathematical knowledge. Pretest data collected from 398 teachers in 15 institutes found significant differences in the baseline mathematical knowledge of these teachers.

Data analysis of the pretest and posttest scores indicated that approximately 33% of institutes had teachers who did not perform better on the posttest than on the pretest;

approximately 50% of the "institutes had teachers who gained between a third and two thirds of a standard deviation on the scale representing content knowledge for teaching; about one sixth of institutes had teachers who gained, on average, a standard deviation or more" (Hill & Ball, 2004, p. 341). Due to the novelty of the instrument used to measure the mathematical content knowledge of these teachers, subsequent analyses were suggested to account for the influence on outcomes of teacher characteristics and institute characteristics. Characteristics of teachers would include educational background, teaching methods, and motivation while the characteristics of institutes would consist of length, collaboration, attention to classroom-relevant practices, content addressed, usage of mathematical ideas, and the quality of the tasks presented to teachers.

Attention to the mathematical knowledge of K-8 teachers has been advocated by national panels, recent commission reports, and scholarly investigations. Although many studies have reported positive impacts of professional development, a study conducted by Hill (2011) suggested that evidence collected on the effects of professional development on mathematics teachers was mixed with current professional learning opportunities proving only a moderately effective path to the goals of current reform. In her study, Hill investigated the effects of professional development that were designed to influence teachers' mathematical knowledge. The data collected from 461 middle school mathematics teachers portrayed a teacher population that participated in professional development activities, but participated at a minimum level of involvement, with possibly disjointed experiences (Hill, 2011).

In an ideal world, the teachers who needed additional mathematical knowledge would register more often for professional development and engage in learning

opportunities that were expected to be mathematics-intensive. However, results indicate that, as a general rule, these opportunities to increase mathematical knowledge neglect to reach where they are needed the most. After examining two years of data for learning, Hill found that none of the learning opportunities investigated were positively related to increasing teachers' mathematical knowledge for teaching algebra. The results concerning the learning opportunities for algebra also indicated that "teachers from higher-poverty schools tended to lose ground, marginally, over those who did not" (Hill, 2011, p. 222).

Characteristics of quality professional development. Studies have indicated that "teacher success can be fostered through high-quality professional development – professional development that is sustained, connected to practice and school initiatives, focused on academic content, and supportive of strong working relationships among teachers" (Wei, Darling-Hammond, & Adamson, 2010, p. 8). The goal of professional development is to improve the knowledge of teachers so they are empowered to improve their teaching in order for all students to achieve their potential. According to Guskey (2002), teachers are attracted to professional development when they believe that it will increase their knowledge and skills, support their growth, and improve their effectiveness with students. Thoughtful planning followed by attentive implementation with feedback is required to ensure that professional development responds to the learning needs of teachers (Mizell, 2010). In order to effectively develop teachers, additional professional development presented in different forms will have to be provided (Schleicher, 2011).

There is a necessity to build a system of professional development that provides teachers with the tools they need to deliver equitable education for all students. "A

system that implies that teaching is predominantly improvisational, impossible to specify, and developed idiosyncratically through individual experience is no system at all and not at all professional" (Ball & Forzani, 2009, p. 509). Transforming teaching does not just involve high-quality recruiting and initial education; it also requires that those who are now teaching adapt to constantly changing demands. The identification of characteristics of high-quality professional development will assist professional developers in creating strong bridges between theory and practice, professional development and mathematics education, and the current and desired state of instructing and learning mathematics (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003).

During the past two decades, there has been an increase in research literature identifying desirable traits of professional development for teachers. After reviewing the characteristics of effective professional development from different perspectives and disciplines, researchers have identified a broad consensus of the main characteristics of quality professional development. They found that quality professional development for mathematics teachers:

- provides opportunities for teachers to build their content and pedagogical content knowledge and skills and examine practice critically (Blank, 2013; Borko, 2004; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2009; Elmore, 2002; Ingvarson, Meiers, & Beavis, 2005; Loucks-Horsley et al., 2003; Mundry, 2005; NCTM, 2014; Zehetmeier & Krainer, 2011),
- engages teachers as adult learners in active and inquiry-based learning (Blank, 2013; Desimone, 2009; Doerr, Goldsmith, & Lewis, 2010;

Elmore, 2002; Garet et al., 2001; Ingvarson et al., 2005; NCTM, 2014; Zehetmeier & Krainer, 2011),

- provides opportunities for teachers to collaborate with colleagues and other experts to improve their practice (Birman, Desimone, Porter & Garet, 2000; Blank, 2013; Darling-Hammond et al., 2009; Desimone, 2009; Doer et. al, 2010; Elmore, 2002; Garet et al, 2001; Ingvarson et al., 2005; NCTM, 2014; Saunders, 2014),
- includes a sustained investment of time for professional learning (Bell, Wilson, Higgins, & McCoach, 2010; Blank, 2013; Darling-Hammond et al., 2009; Desimone, 2009; Elmore, 2002; NCTM 2014; National Research Council, 2011; Saunders, 2014),
- maintains coherence with other parts of the education system (Darling-Hammond et al., 2009; Desimone, 2009; Loucks-Horsley et al., 2003; NCTM, 2014), and
- utilizes data and evaluation (Elmore, 2002; Ingvarson et al., 2005; Loucks-Horsley et al., 2003; Saunders, 2014).

Details of how these characteristics can be utilized to design quality professional development for mathematics teachers are described below.

Builds teacher content and pedagogical content knowledge. To foster the conceptual understanding of students, it is essential that teachers have a rich and flexible knowledge of the content they teach (Borko, 2004). Content knowledge describes the quantity and organization of knowledge in the area taught by a teacher. Shulman (1986) noted:

> The teacher need not only understand that something is so; the teacher must further understand why it is so, on what grounds its warrant can be asserted, and under what circumstances our belief in its justification can be weakened and even denied. Moreover, we expect the teacher to understand why a given topic is particularly central to a discipline whereas another may be somewhat peripheral. (p. 9)

Experts have debated what particular type of content knowledge mathematics teachers need to have to be effective in the classroom. However, they generally agree that knowledge required for effective teaching includes teacher knowledge in the form of specific content knowledge and pedagogical content knowledge or expertise in instructional practices that focus on problems of teaching and learning associated with specific subjects (Ball, Thames, & Phelps, 2008; Elmore, 2002; Scher & O'Reilly, 2009).

Professional development should help mathematics teachers develop an understanding of the essential concepts of the subject and how these concepts are connected. In order to use instructional materials astutely, to assess students' growth, and to make sound decisions about presentation, emphasis, and sequencing, teachers must have pedagogical and content knowledge of mathematics. Empirical research addressing the issue of teacher knowledge and practice provides support that student achievement will not improve without changes in teacher knowledge and practice. Research by Ball, Hill, and Bass (2005) found that the "size of the effect of teachers' mathematical knowledge for teaching was comparable to the size of the effect of socioeconomic status on student gain scores" (p. 44). This is an encouraging finding, because it suggests that

one way to close the achievement gap of children from low socioeconomic status could be through improving teacher knowledge.

Mathematics teachers must be able to select appropriate tasks, evaluate the advantages of particular representations of a mathematical concept, assist students in making connections among mathematical ideas, and understand and respond to the mathematical arguments and solutions of students. Lacking mathematical content knowledge can hinder the abilities of teachers as they review and analyze their students' mathematical thinking, create activities to increase students' understanding, or participate in productive professional discussions. Improved mathematical knowledge can also assist teachers in connecting mathematics to classroom practice as they utilize new curriculum resources, explore mathematical lessons, and analyze the mathematical thinking of students (Doerr et al., 2010).

Engages teachers in active learning. Teachers who are skeptical about reform mathematics teaching can be convinced of the effectiveness of these methods through quality professional development in which they are "participating in mathematical challenges/adult problems with their 'student hats' on, engaging in investigative activities for their particular grade levels, and reading and discussing articles that set forth the theoretical and research basis for changing practices" (Martin, Structchens, Woolley, & Gilbert, 2011, p. 291). Professional development that allows teachers to experience their own mathematical growth in these ways will lead to increased teacher engagement, which leads to teacher transformation and ultimately to the improved motivation and achievement of students.

Engaging teachers as learners and promoting the development of essential beliefs, habits, and dispositions are necessary to improve teachers' practice. The beliefs of teachers about "mathematics, curriculum, and students' capacity for learning all influence what teachers learn from professional development opportunities. Likewise, teachers' dispositions and habits of mind, including habits of inquiry, curiosity, self-monitoring, attention to students' thinking and experimentation" (Doerr et al., 2010, p. 2) impact their learning from professional development opportunities.

Thompson and Zeuli (1999) describe several requirements that are crucial for professional development to create these transformative learning experiences for teachers. A high level of cognitive dissonance is needed to disrupt the balance between the current beliefs and practices of teachers and the new information gained about students, content, or learning. Sufficient time, structure, and support are also required for teachers to discuss, challenge, and make sense of the dissonance they experience. The dissonance creating and resolving experiences should be embedded in the teachers' learning by providing activities where teachers utilize student work or engage in student investigations as learners. Teachers also need to have opportunities to "develop a new repertoire of practice that fits with their new understanding" (Loucks-Horsley et al., 2003, p. 45). This enables teachers to apply their new understanding to changes in practice. Teachers should also be engaged in a continuous process of improvement which includes identifying problems concerning teaching and learning, working through these problems to develop new understanding, making alterations in their teaching practice, and recycling through these steps (Loucks-Horsley et al., 2003).

Provides opportunities to collaborate. Given the "prevalence of an 'egg-crate model' of instruction – whereby each teacher spends most of the day in a single room, separated from other adults – the American teaching profession has not yet developed a strong tradition of professional collaboration" (Darling-Hammond et al., 2009, p. 11). Historically, schools have been designed so that teachers work alone with little time allotted to planning lessons, sharing instructional practices, evaluating student learning, designing curriculum, or assisting in administrative decisions. However, in the twenty-first century it is not pedagogically effective or economically sustainable for teachers to work in isolation to meet the numerous needs of all their students (Carroll, Fulton, & Doerr, 2010).

Professional development can support the ongoing learning of teachers by promoting the building of collegial relationships and structures for collaboration. Collaborating with "colleagues can spark the need for teachers to explain their practices and to articulate rationales for instructional decisions, helping teachers make tacit ideas visible and subject to shared scrutiny and develop deeper, more widely shared understandings of students' learning" (Doerr et al., 2010, pp. 2-3). Relationships built through shared inquiry into practice can enhance teachers' sense of competence as they participate in activities to change practice.

Includes a sustained investment of time for professional learning. Professional development must be of sufficient duration, including both time span and the specific number of hours, to promote intellectual and pedagogical change (Desimone, 2009). Researchers advocate sustained professional development in order to have a greater impact on influencing teacher practices which ultimately leads to increases in student

learning. Intensive professional development programs averaging 49 hours per year have been shown to boost student achievement by nearly 21 percentile points while other professional development programs with durations ranging from 5 to 14 hours have not shown any statistically significant effects on the learning of students (Darling-Hammond et al., 2009).

While it is clear that effective professional development requires ample time, it is critical that the allotted time is spent wisely on worthwhile activities that provide creative learning opportunities for teachers. Sufficient time is required for teachers to reflect on and make sense of dissonance-creating learning experiences generated during professional development (Loucks-Horsley et al., 2003).

Maintains coherence with other parts of the education system. Professional development is more effective when it is an integral part of a larger school reform effort, rather than isolated activities that have little to do with other initiatives underway at teachers' schools. If teachers sense a disconnect between what is suggested in professional development activities and what is required "according to local curriculum guidelines, texts, assessment practices, and so on – that is, if they cannot easily implement the strategies they learn, and the new practices are not supported or reinforced – then the professional development tends to have little impact" (Darling-Hammond et al., 2009, p. 10).

Effective professional development must provide teachers with a method to directly apply what they learn to their teaching. Research finds that effective instruction and improved student learning occur when professional development connects to the curriculum resources that are utilized by teachers, the district and state academic

standards that guide their instruction, and the assessment and accountability measures that evaluate their success (Holland, 2005).

Utilizes data and evaluations. Professional development experiences are characterized as effective when their focus and priorities are determined by data related to student learning. Analyzing data will ensure that professional development positively impacts teachers, students, leaders, and the school community (Loucks-Horsley et al., 2003). Research conducted by Strahan (2003) found that the central dynamic in the development of a school's ability to coordinate efforts to improve instruction and strengthen professional learning communities was "data-directed dialogue, purposeful conversation, guided by formal assessment and informal observation, that connected the ways adults and students cared for each other and that provided energy to sustain their efforts" (p. 127).

University/School Collaborations

University/school partnerships are vital components of school reform due to the fact that they have the potential to enrich the professional development of teachers and thus nurture student learning. Although it would seem that universities and schools would be natural partners in preparing and providing professional development for teachers, "for many years, the dichotomy between the 'ivory tower' of the university and the 'trenches' of the public school has been both an ideological perception and a reality" (Rakow & Robinson, 1997, p. 64).

In 2010, the Conference Board of the Mathematical Sciences (CBMS) recommended that institutions involved in preparing mathematics teachers or offering professional development for mathematics teachers recognize teacher education as an

important component of the mission of their mathematics departments. Partnerships between mathematics faculty and mathematics education faculty were encouraged as the CBMS acknowledged that mathematics education could be strengthened by the development of a mathematics education community committed to collaborating in an effort to enhance mathematics instruction at all levels (CBMS, 2012). Gronski and Pigg (2000) defined collaboration as "an interactive process among individuals and organizations with diverse expertise and resources, joining together to devise and execute plans for common goals as well as to generate solutions for complex problems" (p. 783).

Developing university/school collaborations is similar to building a house. Before construction of a house begins, it is critical that the foundation be well planned, level, and firmly seated. If the foundation materials are inferior or the construction of poor quality, the building will not be able to endure storms. "Each beam needs to be capable of carrying its weight, and it is the combined strength of all the pieces that gives the structure its integrity. But even the best-constructed house, if not maintained, will soon fall into disrepair" (Rakow & Robinson, 1997, p. 69). University/school collaborations must be built and maintained with a strong foundation of research and solid instructional practices.

There is not a universal recipe for establishing university/school partnerships that sustain themselves and accomplish their goals. However, several key factors have been identified as essential to developing successful university/school partnerships. These factors include respect and trust between and among those involved in the partnership, visionary leadership centered on knowledge and desired outcomes, deep commitment of interests that are supported by collaborative relationships, readiness to endorse change

and be flexible to accomplish common goals, open communication, development of an environment conducive to the learning of adults, and committed and stable leadership. Ineffective practices that influence partnership viability are characterized by the lack of a common vision, empowerment, collaboration, stability, balance of power, honesty, trust, communication, feedback, and evaluation of progress (MacDonald & Dorr, 2006; Peel, Peel, & Baker, 2002).

The Mathematics and Science Partnership (MSP) program was established in 2002 in response to the No Child Left Behind Act of 2001 in order to create partnerships between K-12 school districts and science, technology, engineering, and mathematics departments from institutions of higher education (see Figure 1 below). The MSP program funds university/school partnerships for "the purpose of providing intensive content-rich professional development to teachers and other educators, thus improving classroom instruction and ultimately student achievement in mathematics and science" (Abt Associates Inc., 2011, p. i). Since 2001, the MSP program has provided professional development services in mathematics and science to an average of 52,000 educators annually and has impacted over 7.8 million students (Abt Associates Inc., Minner, Bobronnikov, Donoghue, Fried, & Morris, 2012).

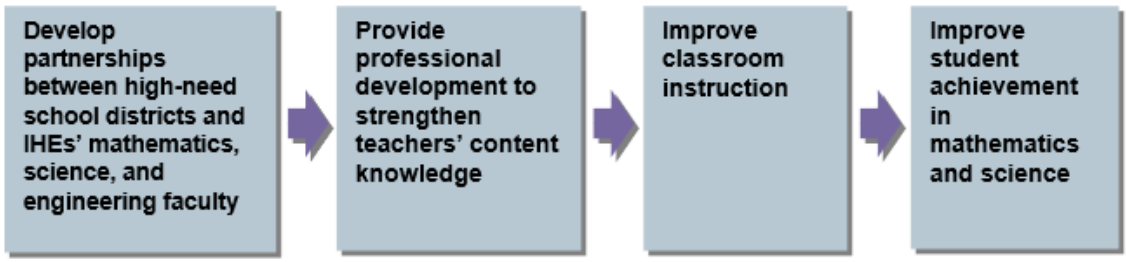

Figure 1. Conceptual model of the Mathematics and Science Partnership program (Bobronnikov et al., 2014, p. 7. Reprinted with permission.).

MSP projects are guided by features of effective professional development programs as they aim to increase science and mathematics teacher content knowledge, promote teaching skills, conduct summer institutes and follow-up, develop curriculum that is aligned to state and local standards, establish distance learning, promote peer mentoring by teachers, establish programs to connect mathematics and science teachers with STEM professionals, develop exemplary K-8 mathematics and science teachers, encourage underrepresented individuals to enter STEM fields, and recruit science, math, and engineering majors into the teaching field (Abt Associates Inc. et al., 2012).

Widespread improvement in the mathematics and science content knowledge of K-12 teachers was shown across all active MSP projects in the reporting period 2009-2010. Based on the results reported for pre- and post- professional development comparisons of teacher content knowledge, in 82% of states reporting, 62% of the participating teachers demonstrated significant gains in their content knowledge of mathematics and in 85% of the states reporting, 71% of the participating teachers showed significant gains in their content knowledge of science. Substantial increases in the mathematics and science proficiency of these teachers' students were also reported with 64% of the students scoring at the proficient level in mathematics and 63% of the students scoring at the proficient level in science (Abt Associates Inc. et al., 2012).

After conducting case studies of several MSP projects, Weiss et al. (2010) identified several lessons that leaders of university/school partnerships should consider when planning and implementing educational reform for mathematics and science in order to increase their chances of producing sustained change in the contexts they were working. Weiss et al. (2010) found that it was important for partner organizations to

recognize that productive university/school partnerships are developed and nurtured over time. Each of the universities and schools included in these strategic alliances must perceive that the partnership is beneficial for its institution. Identifying common ground, developing a shared vision, and sustaining mutual commitment to the reform process are important components of productive partnerships. It is also vital that these partnerships receive support from a range of important stakeholders. The school principals' support of these partnerships impacts the likelihood that their teachers will participate in content-focused professional development and apply their acquired knowledge and skills into their practice. The support of department chairs and colleagues also influences university faculty members' time commitment and energy allotted to launching and sustaining university/school partnerships (Weiss et al., 2010).

Ensuring that the vision underlying the reform efforts is well-aligned with the key policies in the system, including state and district policies, is another significant factor that university/school partnerships should consider when designing professional development programs to improve the content knowledge and pedagogical skills of teachers. In order to impact sustained change in mathematics and science education, Weiss et al. (2010) found that university/school partnerships have to strategically design and implement professional development by selecting interventions that address the perceived needs of the partner districts, recognizing the advantages and disadvantages of offering incentives for teachers participating in professional development, planning strategies to accommodate the varying levels of the participating teachers' content knowledge and skills, and providing support to ensure that the participating teachers

effectively apply their acquired content knowledge and pedagogical skills in their work with students.

Information gathered by Weiss et al. (2010) indicated that university/school partnerships increased the likelihood of sustained improvement when these programs incorporated the use of data to inform decisions concerning the selection, implementation, and adaption of intervention to ensure an adequate level of quality while implementing and scaling-up the intervention and to provide evidence to foster support for system change. With the goal of developing teachers' content knowledge and pedagogical skills, university/school partnerships need to develop plans to safeguard the sustainability of their endeavors. According to Weiss et al. (2010):

> Reform leaders cannot expect that the interventions they develop will remain fully intact once substantial funding from grants such as the MSP has ended. But they can work to leave partners with a *vision* of what mathematics and science instruction should look like, the *will* to continue pursuing that vision through whatever means are available, some *models* that may be used or adapted to enact the vision, and the *capacity* to implement these models. (p. 26)

Implications

This literature review of the factors, including social and political factors, impacting mathematics education; the research results of studies on professional development programs for mathematics teachers; the characteristics of effective professional development; and the lessons learned from studying university/school partnerships was instrumental in studying the evolution and key components of the

professional development offered by the university summer campus program in this study.

Since its establishment, the university summer campus program in this study has had to transform itself to meet the demands of social and political factors and mathematics reform. The literature review of the factors, including social and political factors, which influenced mathematics education was essential in analyzing the evolution of the program studied.

The literature review also included the mixed results found by researchers investigating professional development programs for mathematics teachers (Desimone et al., 2002; Garet et al., 2001; Hill, 2011; Hill & Ball, 2004; Weiss et al., 2001). Research studies have identified several characteristics of effective professional development which promote teacher learning. The literature review of these characteristics enhanced my understanding of the key components needed to sustain a university summer campus program that offers professional development for mathematics teachers.

The information gathered from the literature review assisted in guiding the reporting and analysis of data collected in this study. By studying the evolution and key components of the University School Mathematics Project School Summer Campus Program, significant knowledge can be attained to support other K-12 mathematics professional development programs in developing sustainable programs and to add to the field of study on professional development.

Summary

A historical look at mathematics education provides "clues to factors that may still be in operation today, to currents and forces that move our discipline, and to motives

and conflicts that shape it" (Lambdin & Walcott, 2007, p. 22). The early twentieth-century view of a mathematics teacher as anyone who could follow a textbook and spend the majority of class time on drills in algebraic manipulation and memorized geometric theorems has evolved to the twenty-first century view that a mathematics teacher must be highly qualified, possess deep content knowledge, and have well developed instructional skills to provide mathematics instruction to all learners. Concerns about America's economy, national security, and social justice have swayed citizens, educators, and politicians to recommend changes in mathematics education. Along with these changes comes the realization that if the recommended changes in the mathematics curriculum are to be successful, mathematics teachers will need high-quality professional development that provides the tools required to meet the changing demands of mathematics reform.

Although millions of hours and dollars are spent on professional development, a review of the literature on the impact of professional development on mathematics teachers has been mixed. Identifying the characteristics of high-quality professional development can assist in creating professional development programs that create strong connections between theory and practice. The key components of the consensus view of high-quality professional development include providing opportunities for teachers to build their content and pedagogical content knowledge and skills and examine practice critically, engaging teachers as adult learners in active and inquiry-based learning, providing opportunities for teachers to collaborate with colleagues and other experts to improve their practice, providing a sustained investment of time for professional learning, maintaining coherence with other parts of the education system, and utilizing data and

evaluation (e.g., Desimone, 2009; Doer et. al, 2010; Elmore, 2002; Ingvarson et al., 2005; Loucks-Horsley et al., 2003; Saunders, 2014).

With the increased focus on intensive and sustained professional development for teachers, the MSP program provides funds for university/school partnerships. One of the key goals for the MSP program is the commitment to professional development that deepens teachers' content knowledge to improve student learning through stronger instruction. After conducting case studies of MSP programs, Weiss et al. (2010) identified several lessons that should be considered when planning and implementing university/school partnerships to increase the likelihood of significant and sustained improvement in the content knowledge of the participating teachers. These lessons included recognizing that productive partnerships take time to develop, considering engaging a range of vital stakeholders whose support is vital to deepen the content knowledge of teachers, helping ensure the alignment of key policies in the system with the vision fundamental to the reform efforts, designing and implementing professional development that is aligned to the projects' goals and is feasible and expected to be effective with teachers in their specific context, using data to inform decisions and provide evidence to promote support for system change, and working to cultivate capacity and infrastructure to improve content knowledge and pedagogical skills of teachers. Sustaining successful university/school partnerships requires extensive collaboration, reflection, and a willingness to make revisions in order to have a positive impact on the learning of teachers and students.

The next chapter will discuss the methods used to analyze the data collected while conducting historical research on the evolution of the University School Mathematics

Project Summer Campus Program. The data were utilized to investigate the factors, including social and political factors, which impacted the evolution of this program and to identify the components of the program that contributed to the sustainability of this university summer campus program for K-12 mathematics teachers.

Chapter III

Methodology

> *Through historical analysis we may gain some perspective on the forces and issues that contribute to change in education. Historical perspective helps us avoid tunnel vision about the uniqueness of the educational problems we face today and suggests options to be considered as we ponder their solutions.* (Lambdin & Walcott, 2007, p. 3)

Weaknesses in the mathematics education of students in the United States are often blamed on teachers' lack of mathematical knowledge (Ball, Lubienski, & Mewborn, 2001). Improving the professional learning of teachers is a critical step in transforming schools and improving the academic achievement of students (Wei et al., 2009). The concern for teacher quality prompted the requirement by the No Child Left Behind Act to have a highly-qualified teacher in every classroom (Darling-Hammond & Sykes, 2003). In order to meet these federal requirements and public expectations for school and student performance, the skills and knowledge of teachers need to be strengthened to ensure that all teachers are "able to teach increasingly diverse learners, knowledgeable about student learning, competent in complex core academic content, and skillful at the craft of teaching" (Wei et al., 2009, p. ii).

With the understanding that highly-qualified teachers are the critical component in student achievement, the University School Mathematics Project Summer Campus Program (USMP SCP) has provided professional development for mathematics teachers for almost three decades. This qualitative research study involved examining archival documents and conducting interviews to study the evolution of the USMP SCP. Through

this study, I investigated the factors, including social and political factors, which impacted the evolution of this program and identified components of the program that have contributed to the sustainability of the USMP SCP for K-12 teachers.

In this study, I had various roles. I am a member of the University School Mathematics Project staff and have served as one of the master teachers for the USMP SCP since 1990. The role of a master teacher in this program includes being responsible for several tasks such as assisting in the development of curriculum materials and resources, gauging the abilities of individual participants, and co-teaching lessons designed to enhance both the mathematical content and pedagogical skills of participants (Cruz et al., 2013). In my role as researcher, I obtained and analyzed historical data and conducted interviews to study the evolution of the USMP SCP.

The following sections describe in detail the type of design, context, participants, data collected, and data analysis procedures for this study.

Type of Design

In order to study the evolution of the USMP SCP, a qualitative research design was utilized that incorporated components of case study, narrative, and historical research. A qualitative research design was selected for this study, because it emphasizes holistic description and focuses primarily on collecting evidence of what people say and what they do to illuminate issues and gain understanding (Gillham, 2010). Qualitative researchers tend to collect their data by going directly to the actual setting of interest, because they are concerned with context. The data collected is predominantly words or pictures instead of numbers. Data collected for this type of research can include interview transcripts, audio recordings, memos, photographs, or any other data that would lend

insight to the study. Qualitative researchers are especially concerned with the process or how things occur. They are prone "to observe how people interact with each other; how certain kinds of questions are answered; the meanings that people give to certain words and actions; [and] how people's attitudes are translated into actions" (Fraenkel, Wallen, & Hyun, 2012, p. 427). Qualitative researchers have a tendency to analyze their data inductively rather than formulate hypotheses in advance. They are interested in capturing the thinking of the study's participants from the participants' viewpoints rather than only recording the researchers' thoughts (Fraenkel et al., 2012).

Since this study focused on one particular university summer campus program, components of case study were utilized. A case study is the extensive study of an individual or group through the collection of a variety of data that are used to organize evidence to formulate interpretations relevant to the specific case or to provide valuable generalizations (Fraenkel et al., 2012; Gillham, 2010). The defining trait of case study research is the researcher's focus on obtaining data to describe, understand, predict, and/or manage the individual case (Woodside, 2010). By focusing specifically on the USMP SCP, it is hoped that constructive information will be gained that will benefit other university summer campus programs for K-12 mathematics teachers.

Elements of narrative research were also included in this study. In narrative research, the researcher collects personal reflections of experiences and their causes and effects from one person or several individuals. Narrative researchers focus on each "individual, often describe special or important events in the individual's life, place the individual within a historical context, and try to place themselves in the research by acknowledging that the research is their interpretation of the participant's life" (Fraenkel

et al., 2012, p. 432). Vital parts of the data collected for this study were the participants' reflections on their experiences during the USMP SCP.

History's ability "to employ the past to predict the future, and to use the present to explain the past, gives it a dual and unique quality which makes it especially useful for all sorts of scholarly study and research" (Cohen & Manion,1996, p. 45). According to Fraenkel et al. (2012), historical research is "the systematic collection and objective evaluation of data related to past occurrences to examine causes, effects, or trends of those events that may help explain present events and anticipate future events" (p. G-4). The historical component of this research design was selected because, by studying the evolution of the USMP SCP, I hoped to achieve a better understanding of the factors, including social and political factors, which necessitated changes in the program and the components of the program that contributed to its sustainability. Through this research study, information can be gleaned that will benefit the USMP SCP as well as other university summer campus programs in the development of future professional development programs for K-12 mathematics teachers.

The steps involved in the historical component of this research study involved defining the questions to be investigated, identifying relevant sources of historical data, analyzing and summarizing the data collected from these sources, and interpreting and presenting this information (Borg & Gall, 1989; Fraenkel et al., 2012).

The specific research questions addressed in this study are:

1. How did the University School Mathematics Project's Summer Campus Program for K-12 mathematics teachers evolve to meet the demands of mathematics reform?

2. What factors, including social and political factors, have impacted the evolution of the University School Mathematics Project's Summer Campus Program?
3. What components of the University School Mathematics Project's Summer Campus Program have contributed to the sustainability of the university summer campus program for K-12 mathematics teachers?

In order to answer the questions in this study, historical documentation from a variety of sources, including archival data, was retrieved; descriptive surveys were administered; a focus group was held; and interviews were conducted.

Research Context

The University School Mathematics Project (USMP) was established in 1987 as a bridge between the university's mathematics research community and area mathematics teachers. Since its formation, the USMP has prepared mathematics teachers to join a collaborative network of highly-skilled, K-12 mathematics educators capable of providing effective mathematics instruction to all students regardless of gender, race, socioeconomic status, mathematics aptitude, or prior success in mathematics (Cruz et al., 2013).

The mission of the USMP is to enhance teachers' and school administrators' understanding of the nature of mathematics and provide effective teaching and assessment of mathematics to prepare all students for success as they encounter mathematics in important ways throughout today's society (Cruz et al., 2013). To achieve this mission, the USMP offers a diverse selection of programs including the USMP SCP for K-12 mathematics teachers. With emphasis on problem solving, real-world

applications, and use of manipulatives and technology in the mathematics classroom, the USMP SCP provides professional development which focuses on concept-based learning activities.

The USMP SCP was selected for this study due to its long history of providing professional development to mathematics teachers. While its goal of enhancing the mathematical knowledge of teachers has remained the same, the manner in which the USMP SCP achieves this goal has undergone substantial changes since 1987. The evolution of the USMP SCP from 1987 to 2014 was investigated during this study.

Participants of the Study

In order to investigate the evolution of the USMP SCP, it was important to obtain information from several participants of the USMP SCP and those who were involved in the planning and/or implementing of the USMP SCP during different periods of time. Therefore, purposive sampling was utilized to select participants who were uniquely suited to provide information for this study. The selection of the participants for this study was accomplished by balancing the goals of the research with the realities of time limitations and physical logistics. The three specific populations that I targeted to provide essential information for this study included administrators, master teachers, and participants of the USMP SCP. The members of these targeted groups had unique views of the USMP SCP and provided rich details about their experiences with the program.

USMP SCP administrators. The administrators for the USMP SCP play a key role in obtaining funds, selecting master teachers, planning the curriculum, and implementing the program. Two USMP SCP administrators were purposively selected for this study based on their years of experience with the program. The USMP SCP

administrators selected for this study were Dr. Gianakos (pseudonym) and Mr. Parker (pseudonym). Each of these administrators has been involved with the USMP SCP for over two decades and continues to serve as an administrator for the program. Their unique knowledge of the historical background of the program was fundamental to studying the evolution of the USMP SCP.

USMP SCP master teachers. Master teachers are important components of the USMP SCP and were important primary sources for this study' data collection. The master teachers plan and provide professional development during the USMP SCP. In order to have a diverse group of master teachers who could provide eyewitness accounts of their involvement in the USMP SCP, several factors were taken into consideration. The selection of the three master teachers for this study was based on their number of years of experience as master teachers in the USMP SCP, the specific grade levels they taught, and the periods of time that they taught in the USMP SCP. In order to collect information vital to this study, it was important to have input from master teachers who provided instruction at different levels and had the opportunity to observe and participate in the evolution of the USMP SCP by serving as master teachers for several years. The master teachers selected for this study were Mr. Sullivan (pseudonym), Mrs. Walters (pseudonym), and Mrs. Carpenter (pseudonym).

USMP SCP participants. The participants of the USMP SCP comprise a diverse group of mathematics teachers from various levels and school districts. In order to get different perspectives than those of the administrators and the master teachers who participated in this study, a diverse group of participants of the USMP SCP was selected to provide information describing the evolution of the USMP SCP. Although their views

of the program were limited to the time of their participation, they were able to contribute information about factors, including social and political factors, which may have influenced their participation in the program and the components of the program that were meaningful to them.

Five USMP SCP participants constituted the purposive sample for this study. The participants' years of participation in the USMP SCP and the levels of their class were important criteria for selecting participants who could provide valuable information for this study. The participants were selected in such a manner that each of the levels taught during the USMP SCP – elementary, intermediate, middle school, and high school – were represented by at least one participant. Although only five USMP SCP participants were selected for this study, their attendance during different classes and different time periods allowed me to collect data on at least 11 years of the program ranging from 1993 to 2013.

Sources of Data

Historical research is frequently like detective work. The discovery of one bit of evidence leads to seeking out other pieces of evidence. Some of these will produce helpful leads in answering the research questions, while others may not provide useful information (Baker & Benjamin Jr., 2008). There are generally four types of historical source materials: documents, numerical or quantitative records, oral records and statements, and relics (Borg & Gall, 1989; Fraenkel et al., 2012). For this historical research study, data were collected from a variety of these types of historical source materials, and the facts were analyzed to tell the story of the evolution of the USMP SCP.

To tell this story, historical information concerning the USMP SCP was collected by examining archived data related to the program and listening to the voices of the

selected participants of this study through their written responses to open-ended descriptive surveys, which consisted of interview questions, and through their verbal responses given during the interview process. Miles and Huberman (1994) described the importance of verbal data by arguing that "although words may be more unwieldy than numbers, they render more meaning than numbers alone and should be hung on to throughout data analysis" (p. 56).

The visual in Figure 2 represents an overview of the order in which data were collected for this study.

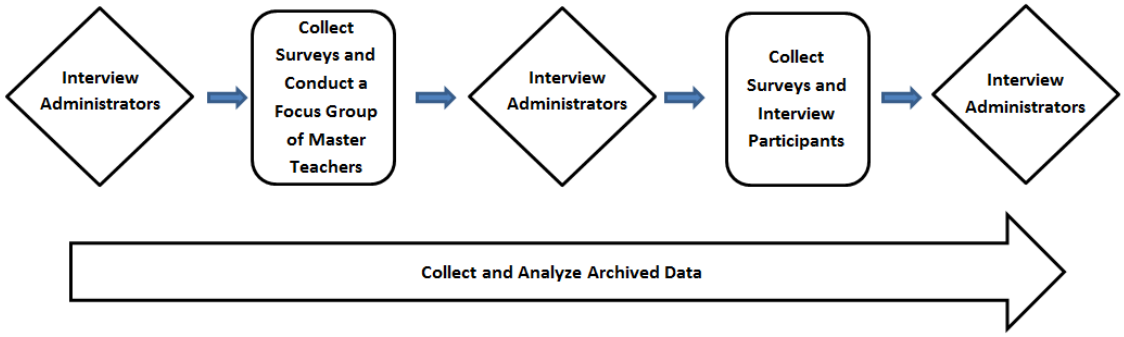

Figure 2. A visual of the timeline for the research design.

Data collected from USMP SCP administrators. As the researcher, I conducted interviews with the selected administrators, master teachers, and participants of the USMP SCP. Three one-hour audio-taped interviews were scheduled with the USMP SCP administrators. The first two of these interviews were semistructured interviews (see Appendix A) in which the administrators answered a series of specific questions concerning the evolution and the administrators' roles in the USMP SCP. The last interview was an informal interview in which the administrators and I cross-explored issues and themes that emerged from collecting historical data and conducting interviews

discussing the evolution of the USMP SCP with master teachers and past participants of the program.

> When describing the mechanics of collecting interview data, Patton (2015) noted: No matter what style of interviewing you use and no matter how carefully you word questions, it all comes to naught if you fail to capture the actual words of the person being interviewed. The raw data of interviews are the actual quotations spoken by interviewees. Nothing can substitute for these data: the actual things said by real people. That's the prize sought by the qualitative inquirer. (p. 471)

Therefore, recording these interviews was essential in order to accurately collect the administrators' verbatim responses. This information was then utilized to transcribe notes that were later analyzed as data for this study.

Data collected from USMP SCP master teachers. To gather additional information for this historical research study, I collected data from a selected group of USMP SCP master teachers through a focus group and descriptive surveys. According to Morgan (1996), focus groups are defined as a "research technique that collects data through group interaction on a topic determined by the researcher" (p. 130). Three components of focus groups are detailed in this definition. First, the definition indicates that focus groups are a method of research dedicated to collecting data. Second, the definition identifies the interaction between the group members as the data source. Third, the definition notes the active role of the researcher in constructing the group discussion to collect data (Morgan, 1996). In this study, I served as the focus group moderator. Fraenkel et al. (2012) indicated that the role of the focus group moderator is critical to

facilitate interaction between the members of the group, elicit different perspectives, and keep the discussions focused on the topic of the study.

The master teachers selected for this study each had at least eight years of experience as master teachers in the USMP SCP, and at least one of these master teachers taught in the USMP SCP during every year from 1988 to 2014. The advantage of using a focus group with the selected USMP SCP master teachers was that the group members had the opportunity to discuss and reflect on their different perspectives on the components of the USMP SCP including goals, curriculum, resources, and impact of the program. They also discussed their opinions concerning the factors, including social and political factors, which may have influenced the evolution of the USMP SCP. Participating in the focus group allowed the selected master teachers to have flexible and exploratory discussions while interacting with the other members of the group.

Prior to the focus group, an open-ended descriptive survey, consisting of the interview questions (see Appendix B), was emailed to each of the selected master teachers of the USMP SCP. Their written responses were submitted to me prior to the focus group. The focus group was audio/video taped in order to capture exactly what was spoken during the discussions and accurately identify the speakers. This recording was then used to prepare a written transcript of the focus group. The written responses from the descriptive surveys and the transcript of the focus group constituted part of the documentation for this study.

Data collected from USMP SCP participants. An oral history of the USMP SCP was also collected by interviewing participants who were involved at different stages of the program. The selected USMP SCP participants had different perspectives of

the program than the USMP SCP administrators or master teachers. As participants of the program, they did not have specific information concerning how or why the USMP SCP was planned and implemented over the last few decades. However, participants from the various years of the program were able to provide details about factors, including social and political factors, which may have led them to register for the USMP SCP, components of the curriculum for the specific summers they attended, similarities and differences between the USMP SCP programs they attended, and the impact of the USMP SCP on them as mathematics educators.

Five participants of the USMP SCP were selected to participate in this study. Descriptive surveys (see Appendix C) consisting of open-ended questions were emailed to the selected participants to give them time to personally reflect on their responses prior to participating in the interviews. These surveys were completed and returned to me. After the written responses were returned, an individual audio-taped telephone or one-on-one interview was conducted with each of the selected participants to give me an opportunity to explore more in depth issues raised from the written responses to the descriptive surveys and to cross-explore issues and themes that may have emerged. Through the interview process, participants were able to share their perceptions of and experiences with the USMP SCP. The audio-recording of each interview ensured that the detail richness of the data was collected in an accurate and retrievable form that could later be transcribed into written form.

To ensure the quality of the data received from the interviews, the same procedures were followed for each interview with the selected participants. These interviews were semistructured so that each participant had the opportunity to respond to

the same open-ended questions asked in the same order, allowing time for follow-up questions if further information was desired or if a participant needed to clarify or elaborate on a specific question.

This type of interview gave me an opportunity to compare and contrast the specific answers given by each of the participants. According to Fraenkel et al. (2012), there are several strengths to using standardized open-ended interviews with the same wording and sequence of questions for all participants. First, respondents are able to answer the same questions which increase the comparability of responses and provide completed data for each person on specific topics addressed in the interview. Second, the effect of the interviewer and bias are reduced. Third, the instrumentation can be reviewed and used in evaluation. The last strength listed was that standardized open-ended interviews facilitate the organization and analysis of the data.

Although there are several strengths to using standardized open-ended interviews, there are a few weaknesses that have to be considered. The limited amount of flexibility in adapting the interviews to specific participants and circumstances and the standardization of the questions' wording as perhaps constraining the "naturalness and relevance of questions and answers" (Fraenkel et al., 2012, p. 453) are listed weaknesses of using standardized open-ended interviews in educational research. In order to address these possible weaknesses, I allowed time towards the end of each interview for me and the participant to engage in informal conversation. This strategy allowed me to match relevant interview questions to each particular participant and gave each participant an opportunity to contribute any additional information that he or she believed was relevant to this study.

Audio recording these interviews reduced the tendency for me, as the researcher, to unconsciously select data that may be biased (Borg & Gall, 1989). Another advantage of using audiotaped interviews included the availability of the tapes for continued study and analysis (Fraenkel et al., 2012). These audiotapes were then transcribed to serve as written documents that were used as sources for data analysis.

Data collected from archived data. Relevant information for this study was also gathered from archived data concerning the USMP SCP. These data included written and printed documents that provided historical information on the USMP SCP such as memos, funding proposals, summaries, and newspaper and journal articles. As a subcategory of documents, numerical or quantitative records were also included in the archived data being examined. These data included attendance figures and budgets for different years of the USMP SCP.

Data Analysis Procedures

According to Ratcliffe (1983), "data do not speak for themselves; there is always an interpreter, or a translator" (p. 149). The theoretical lens that the researcher uses to approach the data, the "strategies that the researcher uses to collect or construct data, and the understandings that the researcher has about what might count as relevant or important data in answering the research question are all analytic processes that influence the data" (Thorne, 2000, p. 68). Historical research, as in other types of qualitative research, requires that the researcher sort through and make sense of the data collected in order to synthesize it into a meaningful story. Important components of this study followed the recommendations of Hammersley and Atkinson who suggested "immersing oneself in the data and then searching out patterns, identifying possible surprising

phenomena, and being sensitive to inconsistencies, such as divergent views offered by different groups of individuals" (Bryman & Burgess, 1994, pp. 6-7).

The first step to analyzing the documents retrieved from archived data began with identifying the data that were most relevant to my research objectives. Guest, Namey, and Mitchell (2013), described content-driven (exploratory) analysis by stating:

> Document analysis can also be inductive, where themes, codes, and items to be recorded are emergent within the data. No predetermined categories – that is, coding attributes – are created. Rather, researchers derive attributes from the data themselves as the analysis progresses, and analyses are typically descriptive in nature, outlining key themes identified in the data. (pp. 256-257)

Through document analysis, I was able to create a chronological timeline describing the evolution of the USMP SCP.

In order to further analyze the data collected for this study, I compared and contrasted written responses given on descriptive surveys, oral statements given during the focus group and interviews, and relevant archived data collected. Descriptive surveys, consisting of the interview questions, were sent to the selected USMP SCP master teachers and participants with a request to have their written responses returned to me prior to the interviews. Audio-taped interviews with the selected USMP SCP master teachers, participants, and administrators served as documentation for this study. Archived data were also used to supplement the information received from the responses given on the descriptive surveys and during the interviews. "Keeping in mind that research questions provide the scaffolding for the investigation and the cornerstone for the analysis of the data" (Anfara Jr., Brown, & Mangione, 2002, p. 31), the interview

questions were constructed by me, the researcher, and revised after receiving input from my committee members.

Table 1 provides a matrix with the research questions for this study shown on the left and to the right of those questions are codes that represent the specific interview questions for the different groups of participants that address those research questions. According to Anfara et al. (2002), it is "imperative that the interview questions be carefully cross-referenced to the study's research questions" (p. 31).

Table 1

Research Questions in Relation to the Interview Questions

Research Questions	Interview/Survey Questions
1. How did the University School Mathematics Project's Summer Campus Program for K-12 mathematics teachers evolve to meet the demands of mathematics reform?	Administrators # 2 Master Teachers # 1 Participants # 1, Participants # 2
2. What factors, including social and political factors, have impacted the evolution of the University School Mathematics Project's Summer Campus Program?	Administrators # 3, Administrators # 4 Master Teachers # 2, Master Teachers # 3 Participants # 3, Participants # 4
3. What components of the University School Mathematics Project's Summer Campus Program have contributed to the sustainability of the university summer campus program for K-12 mathematics teachers?	Administrators # 5 Master Teachers # 4 Participants # 5

By identifying consistencies as well as discrepancies in the data collected, I used content analysis to develop appropriate categories or themes that assisted me in answering the research questions. These categories emerged as I noted the prevalence of certain responses given during the interviews. Content analysis was useful in validating findings from the data sources and shed light on why the data collected might present different perspectives on the evolution of the USMP SCP.

In content analysis, the specification of categories is called coding. Coding occurred as I, the researcher, summarized, synthesized, and sorted the data collected. After collecting the data, my initial steps towards coding consisted of reading through each piece of data collected for this study. After reviewing all of the documents collected from the focus group and interviews, I then reread each of the descriptive surveys and transcripts and assigned codes that succinctly captured the main ideas described in sentences or paragraphs. Each survey or transcript was coded individually before the next piece of data was coded. I then reviewed all of the codes and noticed that many of the codes were related to specific research questions. I then sorted each of the codes into categories that addressed my research questions. These categories were labeled evolution of the USMP SCP, factors impacting the evolution of the USMP SCP, and components that sustained the USMP SCP. After the codes were organized by categories, I then compared and contrasted each of the categories' codes to search for patterns that enabled me to generate themes that captured the essence of similar codes. These themes were used to label the headings in the sections on the evolution of the USMP SCP, the factors impacting the evolution of the USMP SCP, and the components that sustained the USMP SCP.

Several procedures were incorporated to enhance the validity and reliability of this study. Data were accumulated by various methods and triangulation, or the "cross-checking of data using multiple data sources or multiple data-collection procedures" (Fraenkel et al., 2012, p. G-9), occurred during this study. Multiple interviews and surveys with different populations who had varying perspectives on the USMP SCP and the examination of archived data provided a holistic understanding of this university program. Since the data collected from these sources agreed or converged, I was reasonably confident that I was able to get a true picture of the program. According to Gillham (2010), if convergence is not found in the data then it may mean that the picture of the program was more complicated than expected.

Member checking was another component of triangulation for this study. Participants of this study had the opportunity to review the accuracy of the data, analytical categories, interpretations, and conclusions reported in this research study and acknowledge that the reviewed information portrayed accurate pictures of their own realities.

Limitations of the Study

Several factors encountered during this research could limit how the results of this study are interpreted. Since only two administrators, three master teachers, and five participants of the USMP SCP were selected, there is the possibility that the views of the selected participants of this study may not match the perspectives of non-selected participants. There is also the possibility that as the selected participants, master teachers, and administrators attempted to reconstruct from memory their views of the USMP SCP, they may not have been able to accurately provide reliable data for this study.

The use of archived data in this study may also present limitations to this study due to my inability to follow-up with all of the people who generated these documents. By using a variety of sources and types of data, I attempted to minimize the limitations of this study.

Summary

In 1987, the USMP was established as a bridge between the university's mathematics research community and area mathematics teachers. Since its formation, the USMP has offered a summer campus program (USMP SCP) to prepare mathematics teachers to join a collaborative network of highly-skilled, K-12 mathematics educators capable of providing effective mathematics instruction to all students – regardless of gender, race, socioeconomic status, mathematics aptitude, or prior success in mathematics (Cruz et al., 2013).

In the period of time since the USMP SCP was established, it has undergone significant changes in its program. This qualitative research study investigated the evolution of the USMP SCP through the collection of documentation from a variety of sources including archival data, descriptive surveys, interviews, and a focus group. Through the examination and analysis of the collected data, this study addressed how the USMP SCP evolved to meet the demands of mathematical reform; the factors, including social and political factors, which have impacted the evolution of the USMP SCP; and which components of the USMP SCP have contributed to the sustainability of this university summer campus program for K-12 mathematics teachers.

Chapter IV

Results

> *The historical study of an education idea or institution can do much to help us understand how our present educational system has come about; and this kind of understanding can in turn help to establish a sound basis for further progress of change.* (Cohen, Manion, & Morrison, 2007, pp. 191-192)

The changing vision for quality mathematics education heightens the national need to increase teacher knowledge and pedagogical skills (Heck, Banilower, Weiss, & Rosenberg, 2008). The University School Mathematics Project's Summer Campus Program (USMP SCP) is a professional development program designed to enhance the mathematical content knowledge and pedagogical content knowledge of K-12 teachers. Since its establishment in 1987, the USMP SCP has undergone significant changes.

This study was a qualitative study that incorporated components of case study, narrative, and historical research to address three specific research questions.

1. How did the University School Mathematics Project's Summer Campus Program for K-12 mathematics teachers evolve to meet the demands of mathematics reform?
2. What factors, including social and political factors, have impacted the evolution of the University School Mathematics Project's Summer Campus Program?
3. What components of the University School Mathematics Project's Summer Campus Program have contributed to the sustainability of the university summer campus program for K-12 mathematics teachers?

This chapter will include the results of the data collected from historical research, descriptive surveys, interviews, and a focus group.

Participants of this Study

The participants of this study included two USMP SCP administrators, three USMP SCP master teachers, and five past participants of the USMP SCP. Background information on these participants is included in Table 2.

USMP SCP administrators. The selection of Dr. Gianakos (pseudonym) to represent one of the USMP SCP administrators in this study was based on her 28 years of experience with USMP. Dr. Gianakos was a master teacher for the first three years of the USMP SCP before moving into a variety of USMP positions including Coordinator, Director of Research, Executive Director, and Director. As an administrator for the USMP SCP, Dr. Gianakos was able to provide historical information about the origin of the program, procedures involved in obtaining funds, selection of master teachers, and factors involved in curriculum planning and implementation of the USMP SCP program.

Mr. Parker (pseudonym) was also selected for this study as an administrator for the USMP SCP. His selection was based on his 21 years of experience with USMP. Mr. Parker was a participant in the 1988 USMP SCP; a master teacher for a satellite campus of the USMP SCP in 1993 and 1994 and for the high school class of the USMP SCP during 1998 and 1999; and an administrator for the USMP SCP since 1999. In his role as one of the administrators for the USMP SCP, Mr. Parker has been involved in pursuing funding for the program, selecting and mentoring master teachers, assisting in planning and implementing the program, and preserving relevant documents pertaining to the program.

Table 2

Descriptions of the Participants in this Study

Name used in study	Participants' roles in the University School Mathematics Project's Summer Campus Program
Researcher	Master Teacher (1990, Secondary class; 1991-1993, Middle School class; 1994, Elementary class; 1995, Middle School class; 1996, 7-8 class; 1997-1998, 3-4 class; 1999, 5-7 class; 2000, 6-7 class; 2001-2005, 5-6 class; 2006-2007, 5-7 class; 2008, 5-6 class; 2010-2014, 4-6 class) Participant (1988, Middle School class)
Dr. Gianakos	Administrator (1991-present) Master Teacher (1987-1989, High School and Middle School classes)
Mr. Parker	Administrator (1999-present) Master Teacher (1993-1994, Satellite campus; 1998-1999, High School class) Participant (1988, High School class)
Mrs. Carpenter	Master Teacher (1993-1994, Satellite campus; 1996, Kindergarten-2 class; 1997-1998, 7-8 class; 2000, 8-Algebra class; 2001-2002, 7-Algebra class; 2004, Algebra I and Beyond class; 2013, 7-8 class) Participant (1988, High School class)
Mr. Sullivan	Master Teacher (1988-2000 and 2003, High School class)
Mrs. Walters	Master Teacher (1998, Kindergarten-2 class; 1999, 3-4 class; 2000, 3-5 class; 2001-2003, 3-4 class; 2004, PreKindergarten-4 class; 2005-2008, 3-4 class; 2010-2014, K-3 class)
Amy	Participant (2001, 3-4 class; 2010, 7-8 class; 2011, 7-8 class)
Brett	Participant (2008, High School class; 2013, High School class)
Deborah	Participant (1993, Elementary class; 2004, 5-6 class)
Lilly	Participant (2004, 7-8 class; 2005, 5-6 class; 2012, 7-8 class; 2013, 7-8 class)
Lorraine	Participant (1998, 5-6 class; 2007, PreKindergarten-2 class)

USMP SCP master teachers. Master teachers are important components of the USMP SCP and were important primary sources for this study' data collection. The master teachers plan and provide professional development during the USMP SCP. In order to have a diverse group of master teachers who could provide eyewitness accounts of their involvement in the USMP SCP, several factors were taken into consideration. The selection of the three master teachers for this study was based on their number of years of experience as master teachers in the USMP SCP, the specific grade levels they taught, and the periods of time that they taught in the USMP SCP. In order to collect information vital to this study, it was important to have input from master teachers who provided instruction at different levels and had the opportunity to observe and participate in the evolution of the USMP SCP by serving as master teachers for several years. The master teachers selected for this study were Mr. Sullivan (pseudonym), Mrs. Walters (pseudonym), and Mrs. Carpenter (pseudonym).

Mr. Sullivan, a white male, was a master teacher for the USMP SCP from 1988 to 2000 and 2003. During that time, he provided instruction for secondary teachers. Mr. Sullivan was selected to represent a master teacher's viewpoint in this study based on his ability to provide valuable input describing the early years of the USMP SCP during the 1980s and 1990s and to contribute information about the program from a high school teacher's perspective.

Mrs. Walters, an African American female, has been a master teacher for the USMP SCP from 1998 through the present time. During her years as a master teacher, Mrs. Walters has worked with the participating mathematics teachers from elementary schools. Mrs. Walters's input was invaluable as she described changes she had seen in the

USMP SCP during the last 17 years. Mrs. Walters was selected as an USMP SCP master teacher for this study based on her extensive knowledge of the elementary component of the USMP SCP and her ability to provide feedback on how the USMP SCP has evolved during the twenty-first century.

Mrs. Carpenter, a white female, was a master teacher for a satellite campus of the USMP SCP in 1993 and 1994 and the USMP SCP from 1996-1998, 2000-2002, 2004, and 2013. During those times, she was a master teacher for various classes and provided instruction for elementary, middle school, and high school teachers. However, the majority of her time as a master teacher was spent on providing professional development for middle school mathematics teachers. Mrs. Carpenter was specifically selected as a master teacher to participate in this study due to the various levels that she taught and the wide span between her years of experience as an USMP SCP master teacher. With her experience teaching at the different levels and at different time periods, Mrs. Carpenter was in the unique position of being able to contribute information on similarities and differences between the various classes and to elaborate on the many changes that occurred in the USMP SCP between 1996 and 2013. Mrs. Carpenter was also in the unique position of being able to describe similarities and differences in the USMP SCP from a master teacher's perspective as well as from a participant's viewpoint. As a participant in the 1988 USMP SCP for secondary teachers, Mrs. Carpenter had knowledge of the early years of the program as well as the years during which she served as a master teacher for the USMP SCP.

USMP SCP participants. The participants of the USMP SCP comprise a diverse group of mathematics teachers from various levels and school districts. In order to get

different perspectives than those of the USMP SCP administrators and master teachers who participated in this study, a diverse group of participants of the USMP SCP was selected to provide information describing the evolution of the USMP SCP. Although their view of the program was limited to the time of their participation, they were able to contribute information about factors, including social and political factors, which may have influenced their participation in the program and the components of the program that were meaningful to them.

Five USMP SCP participants constituted the purposive sample for this study. The participants' years of participation in the USMP SCP and the levels of their classes were important criteria for selecting participants who could provide valuable information for this study. The participants were selected in such a manner that each of the levels taught during the USMP SCP – elementary, intermediate, middle school, and high school – would be represented by at least one participant. Although only five USMP SCP participants were selected for this study, their attendance during different classes and different time periods allowed me to collect data on at least 11 years of the program ranging from 1993 to 2013.

Amy (pseudonym), an Asian American female, attended the elementary level of the USMP SCP in 2001 and the middle school level in 2010 and 2011. Amy's selection for this study was based on the wide span of years between her participation in the program and the information she could provide about the evolution of the program. Since Amy participated in the elementary and middle school levels of the program, she was able to compare and contrast different levels of the program.

Brett (pseudonym), a white male, attended the high school level of the USMP SCP in 2008 and again in 2013. He was selected to participate in this study due to his ability to compare and contrast the professional development provided during the different years he attended the program. Brett was also selected to give his perspective on the how the high school component of the USMP SCP evolved during the period from 2008 to 2013.

Deborah (pseudonym), an African American female, attended the USMP SCP elementary class in 1993 and the intermediate class in 2004. Deborah was selected for this study to give her perspective on how the USMP SCP evolved between the years of her participation in the program – from the early 1990's to the twenty-first century.

Lilly (pseudonym), a Hispanic/Latino female, attended the USMP SCP middle school class in 2004, the intermediate class in 2005, the middle school class in 2012, and the middle school class in 2013. Lilly was selected for this study because of the wide span between her first and last years of participating in the USMP SCP, the number of USMP SCP courses in which she participated, and the different levels of courses she took. Lilly was able to give specific information on how the middle school component of the USMP SCP evolved during the period from 2004 to 2013.

Lorraine (pseudonym), a Hispanic/Latino female, attended the USMP SCP intermediate class in 1998 and the elementary class in 2007. The selection of Lorraine as a participant for this study was due to the information she could provide about the evolution of the USMP SCP from the late 1990s to 2007. She was also able to provide information about the similarities and differences between the different levels of classes in which she was a participant.

Evolution of the USMP SCP

The USMP SCP was originally established in 1987 as a three-year project to create an alliance between a university and the surrounding school communities. Seed money for this alliance was provided by the National Science Foundation (NSF) through its Teacher Enhancement Program in a comprehensive effort to respond to the educational debate spurred by the report, *A Nation at Risk.* Concerned about challenges to our nation's economy and security and the perceived poor achievement of our nation's students in mathematics and science, NSF anticipated that the Teacher Enhancement Program would improve the quality of education by enhancing the mathematical knowledge of teachers.

Origin of a university/school collaboration. In the original proposal submitted to NSF in 1986 to request funding for the USMP SCP, the principal investigator stated that the purpose of the proposal was to initiate a substantive collaboration between university research mathematical scientists and area precollege mathematics teachers. The project was designed with the anticipation that through the program:

> Mathematics teachers would be brought in contact with contemporary mathematics ideas and with the nationwide effort at revising the mathematics curriculum of the nation's schools. The goal of this interaction is to enhance the mathematical level of the teachers in such a manner that it would improve their scholarship, broaden their understanding of mathematics as a discipline and have a definite positive impact on their classroom interaction with students. (Wells, 1986, Technical Abstract)

The project developers also expected that the USMP SCP would provide a high-quality mathematical model for establishing long term partnerships between university researchers and school systems as a method of enhancing instruction in pre-college mathematics (NSF, 1989).

Factors that influenced the creation of this project were the vigorous debates over mathematics curriculum in American schools, the abundant reform movements in response to the declines in American students' performance on standardized tests, and the scientific and technological demands of society. The need for establishing the USMP SCP was confirmed by the area school district's results on proficiency tests given in mathematics at every level which indicated critical shortcomings in mathematics instruction. In addition to the problem of poor student performance in mathematics, area schools faced an acute shortage of mathematics teachers (Wells, 1986). During the initial years of the USMP SCP, the area school district attempted to address this shortage by encouraging talented elementary teachers to teach mathematics in middle school and urging teachers of middle school mathematics to teach mathematics in high schools. This strategy utilized to staff vacant mathematics teaching positions resulted in some secondary mathematics teachers needing additional professional development and support.

Another factor that concerned the USMP SCP developers was the small percentage of high school students in America who completed one year of calculus. When comparing American students to students in the Soviet Union, Japan, and Germany, Wells (1986) found that these other countries had higher percentages of students graduating from their high schools with training in higher-level mathematics.

The developers of the USMP SCP believed that increasing the number of high school students successfully completing higher-level mathematics would require intensive retraining of mathematics teachers in order for these teachers to convey a novel "sense of vitality to mathematics courses, develop student confidence and minimize 'math anxiety,' emphasize the natural integration of mathematics, and the integration of mathematics with science and technology, and use computers both as tools and as facilitators of learning" (Wells, 1986, p. 2).

With a commitment to improving the teaching of secondary mathematics, the developers of the USMP SCP proposed to address the local and national issues facing mathematics education by forming collaborations between a university and the area school district. The USMP SCP was designed to involve research mathematicians, mathematics educators, and classroom teachers in planning high-quality and relevant mathematical content that would be taught in the program. A unique aspect of the program was that the instruction was provided by six secondary school master teachers who were specifically selected for their positions based on their strong mathematical background and their exemplary teaching. University faculty with expertise in mathematics, statistics, computer science, and mathematics education served as consultants and mentors for the master teachers as they developed curriculum and planned lessons for the summer campus program. The program developers anticipated that through these interactions with university faculty, master teachers would develop a deeper understanding of computer science and advanced mathematics.

The participants selected to attend the program were "potential 'lead' teachers who would likely remain secondary school mathematics teachers (or supervisors) and

who would be actively encouraged to share what was learned in the project with their peers" (Austin, Herbert, & Wells, 1990, pp. 191-192). Special consideration was given to secondary mathematics teachers with only elementary certification. Of the more than 100 secondary mathematics teachers who applied for each of the first two summers of the USMP SCP, a total of 48 middle school and high school teachers were selected each summer to attend the six-week program that focused on mathematical topics related to high school mathematics. The selected participants entered the program with diverse educational backgrounds with an average number of 11.4 years of teaching experience (Austin et al., 1990). The incentives for participants to attend the program included being recognized by their own professional community, having the opportunity to acquire specialized training, receiving graduate credit and a stipend, and obtaining professional development and support through continuation workshops (Wells, 1986).

According to the evaluation report completed by Capper (1987), Director for the Center for Research into Practice, the original design of the USMP SCP was comprised of four main components including lecture workshops, seminars, colloquia, and teaching units. Participating teachers attended lecture workshops Monday through Friday for six weeks. The workshop topics changed every two weeks so that participating teachers were able to attend a total of six different workshops which included linear algebra, algebraic systems, functions, number theory, mathematical induction, and numerical methods. Mr. Parker, the current Executive Director for the USMP, reported that although the middle school and high school teachers were placed into different groups, they received identical content that transcended what was taught in their classrooms. During the focus group with the master teachers, Mr. Sullivan, who was one of the master teachers during the

initial year of the USMP SCP, also reported that some of the lecture workshops were intense and presented material that was at the college level and was beyond anything that was taught in high school. He described the participating teachers in that first summer program:

> The teachers at that time were leaders in the community and a number of them went on to be master teachers here or to lead initiatives other places. So we had a pretty select group and we pushed them pretty hard. (Focus group, August, 2014)

During the first three weeks of the USMP SCP, the participating teachers also met on Monday, Wednesday, and Friday afternoons in small groups for seminars which were chaired by the master teachers. In the seminars, participating teachers read selected materials and presented lessons to the other participants on selected topics such as mathematical modeling, the use of computers in mathematics classrooms, the history of mathematics, and mathematics and medicine. According to Mr. Parker, these "sessions were meant to be self-directed, and the participants could select their own strand" (Interview, April, 2015). The seminars provided opportunities for participating teachers to learn as they taught other teachers. During the Monday, Wednesday, and Friday afternoons of the last three weeks, participating teachers developed and presented teaching units on topics they selected with the guidance and approval of project administrators.

Tuesday and Thursday afternoons were reserved for colloquia in which university faculty and area mathematics educators presented information on historical issues, current research, and global issues impacting mathematics education. Mrs. Carpenter, one of the master teachers who participated in the focus group, referred to the colloquia by

university faculty when she stated that she felt “privileged to have had an opportunity to peek into the minds of these brilliant mathematicians who have come here and shared just a little bit of their work. It is really quite an honor to see them at work” (Focus group, August, 2014).

Another component of the USMP SCP was the follow-up support provided for the participating teachers. During the academic year following the summer campus program, participating teachers and project staff were invited to attend two networking conferences to continue the contact among university faculty, master teachers, and participants and to acquire additional knowledge on current issues in mathematics education through lectures and demonstrations by state and national mathematics educators; and to share ideas and experiences with other mathematics teachers.

Questionnaires given prior to and after completing the program, mathematics tests, interviews, and observations were used to evaluate the effectiveness of the USMP SCP (Austin et al., 1990). Although various forms of assessment were utilized, the information collected consistently revealed that “the participants were extremely enthusiastic about the project, felt that they had been challenged, had learned a lot, and had gained a far greater understanding of mathematics” (Capper, 1987, p.3). The evaluation data also indicated that participants attending the program gained a greater understanding of being a student. Some participants noted the need for well-structured lessons, the importance of time in assimilating and integrating new material, and the need for active involvement in learning. The participating teachers noted that the ideas, concepts, and teaching strategies demonstrated in the program such as the use of calculators and computers and the discovery approach to learning would be incorporated

into their own classrooms. The USMP SCP set the foundation for collaboration between a university and area secondary schools that appeared "to be based on intellectual development, hard work, and mutual respect" (Capper, 1987, p. 11).

Based on information received from questionnaires, interviews, and reflections, recommendations made to refine and enhance the USMP SCP included notifying potential participants of the expected work and time required in the program, allowing time during the first week of the program for participants to start developing their teaching units, allocating additional time for interaction between participants and interaction of participants with university faculty, providing study groups, expanding the "evaluation design to include measures that will allow determination of the impact of the project on the participants' in-classroom teaching behavior, their likelihood of staying in teaching, and the effects on student learning" (Capper, 1987, p. 11). After reviewing all of the evaluation data, Capper (1987) concluded that the USMP SCP "is a thoughtfully conceived project that not only maintains intellectually rigorous standards but also provides a caring and professional environment for advanced learning. The model is quite viable for broader dissemination" (p. 12).

During the second year of the program, corporate funding allowed the USMP to add another element to the summer campus program. With the goal of producing and publishing teaching units, some of the outstanding participants from the previous USMP SCP were selected to return for a second year of the program. These selected teachers participated in a month-long program in which they were able to review teaching software and use their findings to develop teaching units. Although good teaching units were created, Dr. Gianakos reported that there was not cohesion to them:

> Without the time and expertise required to lead the endeavor of developing and publishing teaching units, this component of bringing in teachers during the summer campus program specifically for writing teaching units could not meet its expected goals and was not repeated. (Interview, April, 2015)

Inclusion of elementary teachers. After completing two years of the USMP SCP, the directors of the USMP considered expanding the summer campus program to include a component for elementary teachers. One of the factors prompting this change was the mathematics reform movement of the time based on the National Research Council's (1989) *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* and the draft of the National Council of Teachers of Mathematics' (NCTM, 1989) *Curriculum and Evaluation Standards for School Mathematics.* These publications described the goals of "improving understanding of mathematics by all students and increasing student enrollment in mathematics at the post-elementary level largely through a common curriculum for all students" (Austin, 1992a, p. 1). Mathematical understanding was interpreted by the reform movement "not as computation and rote algorithmic knowledge but as understanding constructed by discovering patterns or by modeling applications and then extending to mathematical relationships or structure" (Austin, 1992a, p. 1). Other factors supporting the addition of an elementary component to USMP SCP was that assessments of students in area elementary schools indicated that these students had poor problem-solving skills, and school personnel noted that lessons for upper elementary students frequently lacked technology or manipulatives.

Elementary and secondary teachers and administrators participated in a symposium to discuss how the USMP SCP could support the elementary school community. Participants of this symposium noted "that while there are many very capable elementary school mathematics teachers, many others have a limited understanding of mathematics and some have an anxiety about mathematics which often is transmitted to their students" (Wells & Austin, 1989, p. 20). The participants of the symposium agreed that the new reforms mandated that elementary teachers have a comprehensive knowledge of mathematics, technology, and teaching for understanding.

In 1989, the USMP developed a four-week summer program for elementary teachers and received funding from several foundations to initiate the program. The goals of the elementary component of the USMP SCP included enhancing the mathematical knowledge of elementary teachers through content and evaluations that were closely based on NCTM's (1989) *Curriculum and Evaluation Standards for School Mathematics*, assisting elementary school teachers in their understanding of mathematics curriculum and implementing the curriculum changes promoted by NCTM, improving the teaching skills of elementary teachers through the use of exemplary master teachers as role models, and emphasizing and using problem solving and inquiry through appropriate use of manipulatives, technology, and applications (Austin, 1992b).

The elementary component of the USMP SCP was led by two teams of master teachers. Each team consisted of an elementary teacher, a middle school teacher, and a high school teacher in an effort to stress the global aspects of mathematics reform. The master teacher at the elementary school level was an important part of the team because of his or her knowledge of the curriculum and manipulatives used effectively with

students in elementary school. The master teacher from the middle school played a vital role in the program by making connections between the elementary and middle school curriculum and informing teachers of the perquisites needed for elementary students to have a successful transition to middle school. The master teacher from the high school level had the significant role of connecting and extending mathematical concepts.

Manipulatives, problem solving, and calculator use were integral parts of the elementary program. Participating teachers also explored the progression of topics from elementary school through middle school and possibly to high school. The participants of the elementary program also attended the colloquia along with the participants of the secondary program. Mathematical assessments, journals, and questionnaires were used to evaluate the elementary program. An elementary teacher commented:

> In teaching, I am very capable in language arts and science but "math anxious" in the area of problem solving and discovery. This course has been an invaluable tool in helping me to overcome my fears of these two areas and to see the great advantage to students in the discovery method. (Austin, 1992b, p. 6)

Similar responses from other participants in the USMP SCP indicated that elementary school teachers benefitted from the summer campus program and developed confidence in implementing lessons and activities associated with the mathematical reforms that were endorsed in *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (National Research Council, 1989) and the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989).

A focus on middle school teachers. During each of the summers from 1987 to 1989, the secondary program of the USMP SCP remained rather consistent. However,

changes in funding necessitated that the 1990 USMP SCP for secondary teachers be reduced to a four-week program with three master teachers providing instruction for only middle school teachers (Austin & Wells, 1991b). According to the proposal requesting funding for the 1990 USMP SCP, the specific goals for the project were:

> To improve the mathematical knowledge skills of … area mathematics teachers necessary to implement state and national reforms; to help teachers use technology in their mathematics teaching; to help teachers implement inquiry-based instructional methods that included problem solving and group work; and to help teachers use a variety of evaluation and feedback methods in their teaching which included student writing, oral reports and student projects. (Austin & Wells, 1990, page i)

My first experience as a master teacher for the USMP SCP was during that summer of 1990. Two other master teachers and I designed the secondary program to prepare middle school teachers to truly implement the revised curriculum and provide instruction consistent with new state and national reforms. We based the curriculum on the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) and the "essential elements" outlined by the state which included the concepts of algebra, functions, statistics, number theory, geometry, sequences, and series.

Another factor impacting the 1990 USMP SCP was the low student achievement, especially among minority students, consistently shown on district assessments. While teachers from minority groups and teachers working in predominately minority schools had attended the summer campus program in previous years, there was a growing concern that the needs of these teachers must be specifically addressed. Therefore, the

directors of the 1990 USMP SCP endeavored to recruit and select middle school mathematics teachers from these populations. When planning our lessons, the other master teachers and I focused on presenting information and teaching strategies that would address the unique needs of students from underrepresented minority racial and ethnic groups. During post-project interviews, several participants "indicated that the project's emphasis on group work, student inquiry, and more flexible evaluation procedures were useful techniques for all students but especially for many minority students" (Austin & Wells, 1991b, p. 14).

A three-pronged program. The elementary and secondary programs of the USMP SCP were "built on local and state needs growing out of revisions in the curriculum and teaching focus mandated by changing technological and societal needs" (Wells & Austin, 1990, p. 20). In an attempt to improve instruction and student achievement, the local school district implemented new programs including a magnet school network, computers in classrooms, and extended day programs. The district also began to upgrade its curriculum to implement district and state standards. An International Baccalaureate program, a rigorous program to prepare students for college, was introduced into several high schools. The honors courses and the International Baccalaureate program required that high school teachers understand and effectively teach the enhanced mathematics curriculum. In order to meet the needs of these teachers, a high school course was reinstated into the USMP SCP.

During the USMP SCP of 1991, the master teachers for the elementary program extended their participants' mathematical understanding of geometry, polygons, and constructions through the use of patterns and manipulatives. Another master teacher and I

used a variety of manipulatives and strategies to develop the middle school teachers' understanding of problem solving, geometry, and line plots while the high school teachers explored data representation, modeling, functions, and linear algebra.

Another change to the USMP SCP was the addition of a mathematics laboratory. The laboratory director, along with the master teachers, planned activities that would allow participants to use manipulatives, calculators, and computers to introduce, reinforce, and extend concepts taught in their course. While many participants acknowledged that their experiences in the mathematics laboratory were rewarding, some commented that more coordination was needed between class instruction and laboratory activities.

During the summer program, a university professor of mathematics attended many sessions at each of the different levels. In her evaluation of the 1991 USMP SCP, Brown (1992) reported that the participants "felt the fact that a Professor of Mathematics attended their sessions validated the importance of elementary, middle, and secondary teachers in mathematics" (p. 37) and the professor "helped the participants, particularly elementary and middle school teachers, realize that the mathematics they were doing in class was 'real' mathematics" (p. 37).

Recruitment of teams from area schools. Although profound differences were made in individual schools and school districts by participants of the program, individual teachers occasionally "found it difficult and frustrating working alone to make changes beyond their own classrooms" (Austin & Wells, 1991a, p. 1). Recognizing that the involvement of principals and administrators was an essential factor in the effective implementation of curriculum and instructional reforms, the directors of the USMP

actively recruited teams from area schools to attend the 1991 summer campus program. While individual teachers were still accepted into the program, preference was given to teams of teachers attending from the same school. The directors hoped that the involvement of teams of teachers and their principals in the summer campus program and academic year follow-up would reduce the resistance to change encountered in some situations. The USMP directors also recognized that the support of principals would be crucial for teachers and students to successfully achieve the changes envisioned in educational reform and multiply "the impact of the program beyond the immediate nucleus of teachers who do participate in the summer programs" (Austin & Wells, 1991a, p. 1).

In 1991, a total of 15 teams, each consisting of an administrator and two teachers from the same school, attended the USMP SCP. While the participating teachers attended classes in the summer campus program, the principals and administrators visited classes and attended events designed to provide them with detailed information on the curriculum and instructional objectives outlined by the mathematics reform movement and give them an opportunity to develop activities to accomplish these objectives. Serving as resources, USMP personnel assisted the school administrators in creating individual plans to improve mathematics instruction on their campuses. During the 1991 USMP SCP, Dr. Gianakos served as the Teams Project Coordinator. After meeting with each of the teams at their schools, Dr. Gianakos:

> Provided resource support: disseminated information on the *Standards*, *Everybody Counts*, the *Mathematics Teacher*, the *Arithmetic Teacher*, problem-solving resources, etc.; assisted teams in developing an inservice program on the

> *Standards*; provided resources on NSF and Eisenhower funding available to support initiatives in mathematics education; provided a list of speakers appropriate for inservice instruction; volunteered to present workshops for inservice programs; provided information on NCTM and state mathematics conferences; discussed how to implement cooperative learning techniques; discussed how to improve students' performance on achievement tests; [and] volunteered to write lesson plans. (Brown, 1992, pp. 40-41)

During an interview, Dr. Gianakos described her work with the school teams:

> They had questions and we could respond. It was like informal action research. Whatever teachers needed, we provided. I would go over to their schools and work on whatever they wanted. One school wanted help with the metric system and another one wanted help with problem solving. It was just an eclectic group of scatter shot things, but that is what they perceived they wanted. So that is what I did. (Interview, September, 2014)

This close working relationship between the USMP and area schools was viewed as a special feature of the USMP SCP and an essential factor in schools' implementation of educational reform.

Introduction of satellite campuses. The idea of extending the USMP SCP onto school campuses was conceived by a participant of the 1991 USMP SCP. The first satellite campus of the USMP SCP originated because of the desire of this participant to create a university/school collaboration program that was similar to the USMP SCP on her inner-city school campus (Brown, 1992). Former USMP SCP participants from a nearby county also expressed interest in increasing teacher participation in the USMP

SCP program. As a result, a satellite campus for the USMP SCP was established in that county at a high school that served predominantly minority students. The following year, an additional satellite campus for the USMP SCP was added in another neighboring school district to assist in creating mathematics leaders and providing real change in the teaching and learning of mathematics in their schools.

According to Wells, Papakonstantinou, and Austin (1994), the goals for these USMP SCP satellite campuses were to expand the number of mathematics teachers receiving professional development from the USMP SCP, to increase the number of participating teachers from targeted schools that had a large population of underrepresented minority students, to provide professional development that would address the specific needs of the various groups, and to "create a system change with administrators, counselors, parents, business partners, and teachers designing and implementing an ongoing program" (p. 10). Funds to establish these USMP SCP satellite campuses were received from the university, local school districts, corporations, and foundations.

Former USMP SCP participants were selected as master teachers for the satellite campuses based on their ability to lead and guide others, their expertise in teaching, and their solid mathematical content knowledge. The master teachers for the satellite campuses worked closely with the USMP SCP master teachers and university faculty to plan the content for their satellite campuses. The participants of these USMP SCP satellite campuses visited the university campus during the USMP SCP to attend colloquia, to participate in hands-on activities in the mathematics laboratory, and to observe demonstrations in the university's computer laboratory (Wells,

Papakonstantinou, & Austin, 1993). The USMP SCP was described by Wells et al. (1993) as having:

> Evolved through three stages: the first stage dealt with training teachers as individuals, the second stage involved teams from a school including administrators so that the impact of the educational reforms on a given school would be enhanced, and finally dealing with whole schools and feeder patterns as well as Satellite Campuses where the goal is to reach all the mathematics teachers in a given region or feeder pattern of schools. (p. 3)

As the number of satellite campuses increased, so did the number of issues involved in the administration of the USMP SCP at these satellite campuses. According to Dr. Gianakos, with the satellite campuses located in several area school districts "there was not enough oversight where we could make changes quickly if we needed to" (Interview, April, 2015) and "it got very difficult to manage high-quality programs and it was too much, so we went back to just ensuring that the USMP SCP is really the centerpiece of USMP" (Interview, September, 2014). Mrs. Carpenter, one of the master teachers who was part of the focus group, gave similar accounts of the USMP SCP at the satellite campuses. She stated that a conscious decision was made to have just the one location for the USMP SCP. Instead of having satellite programs all over the city, the USMP SCP "just needed to be brought back for that control of quality" (Focus group, August, 2014).

Multiple courses offered to address district needs. Starting in 1996, the USMP SCP diverged from just offering three courses for elementary teachers, middle school teachers, and high school teachers to offering at least four to six different courses

designed especially for specific grade bands. This enabled the master teachers to focus on the unique needs of teachers at certain grade bands.

There was a demand for additional professional development of area mathematics teachers due to the dismal passing rates of students on the state assessments, the discrepancies between the mathematics achievement rates of minority students and district averages, the large student dropout rates in local schools, and the low percentage of students mastering algebraic objectives (Wells, Papakonstantinou, & Austin, 1996). The area school district's vision was that all of their high school students would complete a year of algebra before graduating. The USMP SCP directors realized that in order to achieve this vision "the mismatch between the way students learn and the way that they are taught must be addressed" (Wells, Papakonstantinou, & Austin, 1997, p. 11).

As the number of the USMP SCP courses expanded to address the specific needs of different grade bands, the curriculum changed. In the early years, each of the participating teachers received the same content. According to Mr. Parker:

> With the changing requirements, and the changes in types of teachers we had in the program, the content necessarily became much more curriculum focused. . . . The curriculum became more grounded in what was taught in their classrooms on a day to day basis. We still always try to get them to see where the math is going and stretch them beyond their grade level, but as time went on we had to do more divisions by grade level because of that change in focus on the content that the teachers were actually teaching. (Interview, September, 2014)

The USMP SCP designed the specific courses to support participating teachers as they enhanced their mathematical knowledge, discovered appropriate methods of

mathematics instruction, discussed evaluating the mathematical learning of their students, and reflected on how they might change their mathematics instruction. Rather than the teacher-centered and passive-learning approaches frequently used in mathematics instruction, the USMP SCP provided participating teachers with a problem-solving approach to learning mathematics with active student-centered investigations, cooperative groups, and alternative assessments. Participants of the USMP SCP utilized "manipulatives and technology as tools to address various learning styles, to model or represent mathematical concepts, to make conjectures from the manipulative representations, and to generate authentic data" (Wells et al., 1996, p. 6).

During the 1998-1999 and 1999-2000 school years, Dial, an external evaluator, conducted interviews and classroom observations with the teachers who had participated in the 1998 USMP SCP. Dial (2000) reported:

> The three most commonly mentioned problems and challenges that teachers described in previous years were not mentioned as often for the 1998 program. These three are: (1) understanding some of the material at the level it is presented, (2) integrating the information and materials into their classes because of the program's higher level, and (3) knowing how to integrate some of the activities into their curriculum. These were not noted as much in 1997 and even a lesser degree in 1998. The lack of teachers' understanding and their inability to integrate information to their respective grades is probably due to the further specialization on behalf of the program delivery. In other words, breaking down the program into five classes which are based on grades taught has helped. (p. 3)

Changes in the twenty-first century. As America entered the twenty-first century, there was a concern that our country's neediest students were being left behind. The No Child Left Behind Act (NCLB) provided a blueprint to reform the Elementary and Secondary Education Act and link federal funds to specific performance goals to ensure that the needs of all students were being addressed. The priorities outlined in NCLB included improving disadvantaged students' academic performance, enhancing teacher quality, increasing the English fluency of limited English proficient students, promoting innovative programs and knowledgeable parental choice, encouraging safe schools, increasing funds for Impact Aid, and encouraging accountability (Bush, 2001). Understanding that the quality of a teacher is a key factor in improving student achievement, NCLB provided funds to meet the needs of states and local school districts and to enhance public school teachers' knowledge and skills. States became accountable for ensuring that their students were provided instruction by effective teachers. This focus on accountability impacted the USMP SCP.

The faculty and staff of the USMP SCP realized that in order for the program to adequately prepare teachers to meet these new demands, they needed to make adjustments to the curriculum to include conversations concerning national and state standards for curriculum, equitable teaching practices, assessments, and research-based strategies for effective teaching. While these were very worthwhile discussions, it was difficult to incorporate all of these into a four week program. Dr. Gianakos shared some of the frustrations felt by the master teachers during that time:

> We just felt that – there is the saying in education "A mile wide and an inch deep" and we did not want to fall into that. When the program was 6 weeks long, we

> could delve into the mathematics deeply on a few concepts. As the program got shorter, four weeks, it became more difficult to really look at everything that we wanted to. Master teachers were feeling frustrated. They felt that they could not cover everything, although there wasn't a set curriculum. There were some who were very frustrated by that and as a result, we decided several years ago to have two alternating curricula. (Interview, September, 2014)

As Dr. Gianakos explained, in order to provide the support our participating teachers needed to face these new challenges, the curriculum of the USMP SCP was changed from including all of the mathematical strands in one summer program to covering these strands over two summers. The curriculum now alternates between a focus on numbers, operations, quantitative reasoning, patterns, relationships, and algebraic reasoning one summer and a focus on geometry and spatial sense, measurement, data analysis, statistics, and probability the next summer.

Mr. Parker clarified why this new change in the program was met with some apprehension from the surrounding school districts:

> There was some concern when we split into a two-year program because teachers were not getting a full methods course in the summer to be ready to teach the entire year's curriculum. But it was necessary, I think, to delve into things more deeply and provide the two-year cycle. (Interview, September, 2014)

While school administrators were a little hesitant about these changes, so were some of the USMP SCP master teachers. Prior to these changes, the program's curriculum had remained consistent for over a decade. As a master teacher, I was anxious about filling our four-week program with only half of our usual curriculum. What I discovered was

that our program was enhanced as we were able to spend additional time on incorporating technology, book studies, interdisciplinary activities, and class discussions on equity, assessments, and pedagogy and assisting participants in creating learning plans and locating resources that could be used with the students in their classrooms. In addition to the professional development provided each summer, the USMP SCP also incorporated evening meetings during the following academic year to provide additional support for the participating teachers. Dr. Gianakos explained that as school administrators visited classes during the summer program and understood the additional support provided to their teachers, they began to understand the benefits of the changes made to the program:

> Now administrators see that two years is better than one – especially with the academic year follow-up that their teachers are receiving. And we talk about teaching – which we call teacher talk. We did not have that in the early years. . . . Now, we also have common readings which we did not have in the early years – we just did math. (Interview, September, 2014)

Current program. The current USMP SCP is an intensive three-week summer program that "seeks to empower teachers by promoting the investigation of mathematical concepts in the real world, and by linking the mathematics encountered in the classroom to real-world scenarios and applications" (Anderson, 2014). Just as in 1987, the USMP SCP continues to provide a rigorous mathematics instruction program for teachers. However, several components of the program have changed since the establishment of the USMP SCP in 1987. The information in Table 3 delineates some of these changes.

Table 3

Changes in Components of the USMP SCP from 1987 to 2014

Components of the USMP SCP	1987	2014
Length of the program	6 weeks (Mondays through Fridays)	3 weeks (Mondays through Thursdays)
Instructional focus	Mathematics related to high school mathematics courses	Mathematical knowledge for teaching (math content and pedagogy) for specific grade bands
Instructors	1 master teacher for each of the 6 lecture workshops on high-level mathematics which were taken by all participants	2 master teachers for each grade band course (elementary, intermediate, middle school, high school)
Participants	48 mathematics teachers (middle school and high school)	80 mathematics teachers (Kindergarten through 12^{th} grade)
Average years of teaching experience of participants	11 years	6 years
University faculty support	Served as colloquia speakers, planned curriculum, and provided mentoring for master teachers and participants	Served as colloquia speakers
Resources given to participants	Binders and scientific calculators	Manipulatives, resource books, laptops and tablets for K-12 teachers and graphing calculators for middle school and high school teachers
Academic-year follow-up	2 networking conferences	2 networking conferences plus 4 academic-year follow-up sessions

The following section will describe some of the factors that prompted these changes in the USMP SCP.

Factors Impacting the Evolution of the USMP SCP

After researching the history of the USMP SCP, it became evident to me that many factors impacted the evolution of this program. As Dr. Gianakos reflected on the program, she described several factors, including social and political issues, which instigated changes in the USMP SCP:

> All of the new teachers, again teacher shortage has really been the drive behind the summer campus program forever I think, but differently. In the early years, the top teachers moving up to higher grade levels and now the new and/or struggling teachers being able to even teach. Accountability from No Child Left Behind and the Race to the Top and closing the achievement gap were other factors that instigated changes in the program. We had to deal with equity issues. We had to deal with diversity and all of these other issues as a result of what was happening in society. (Interview, September, 2014)

As I examined the data gathered during this research, I realized that many of the other participants in this study described these same factors as prompting changes in the program. The factors described as impacting the evolution of the USMP SCP can be categorized as financial support, changes in the teaching force, accountability, equity, technology, and standards for curriculum.

Financial support. Grants provide the primary source of funding for the USMP SCP. In order to qualify for funds and maintain the financial support, it is important that

the requirements for funding are followed. According to Dr. Gianakos, the USMP SCP was originally established with funding from an NSF Teacher Enhancement grant:

> The Teacher Enhancement grant was a response to the launch of Sputnik and to a *Nation at Risk* to try to get more content into the math and science classrooms in order to compete internationally. We didn't have enough teachers with strong content knowledge to teach the content. We needed more AP classes to accommodate more people going into science and engineering but didn't have the skilled teachers to teach these classes. The focus on STEM in the early years is again the talk today. It seems like we've got a pendulum going. We wanted more STEM focus in order to prepare teachers to prepare students to go into those fields so that we would not be second in the world. (Interview, September, 2014)

In order to meet the requirements of the Teacher Enhancement grant, the USMP SCP focused on enhancing the content knowledge of mathematics teachers. As a participant in the program during that time period, I remember that most of the mathematics presented in the USMP SCP helped me grow mathematically. However, because of the high-level of the mathematics content I was not able to incorporate most of the lessons into my middle school classroom. Dr. Gianakos recalled that the original goal of the USMP SCP was to give teachers more mathematics, because NSF wanted "a workforce that was better educated in mathematics – so it was a math focus. We were trying to get more high school teachers certified to teach math" (Interview, September, 2014).

Although grants provide the main source of funding for the USMP SCP, there is still a need for additional funds that corporations, schools, and school districts provide. Dr. Gianakos described some of the reasons additional funds are necessary:

> Teacher Quality grants have been the main source of funding since the NSF funds ended. Federal funding is very important, because it allows the university to provide tuition waivers through cost-sharing. Without federal funds, we would not be able to grant the graduate credit that we give. However, we need additional funds because we are doing more than is required in the grant. Teachers did not get much more than a stipend, a binder, and a calculator in the olden days. We want to be able to give them many more resources. We really want to give teachers more resources to take back to their classrooms to apply what they learned. We also want the program to more collegial. In the early days, we did not serve meals on a daily basis. So we have to have supplemental funding. (Interview, September, 2014)

Modest supplementary funds from the schools and school districts of participating teachers are now requested to ensure commitment to the program. Mr. Parker stated that the USMP SCP administrators understand that "it is important for schools and school districts to have buy-in into the program. It really is kind of a partnership and they are putting their stake in and we are providing the rest" (Interview, September, 2014).

According to Dr. Gianakos, the USMP SCP would not be valued or taken seriously without the buy-in from schools and school districts. She stated that "a modest amount of money from schools ensures this buy-in. Teachers receive so much more in materials and stipends than this small amount" (Interview, September, 2014).

In Mrs. Carpenter's description of funding as an important factor impacting the USMP SCP, she noted that one issue affected by funding is the amount of the stipend received by each of the participating teachers. Mrs. Carpenter observed that "There have

been lean years and there have been rich years and that makes a huge difference in terms of whether a teacher who is financially needing an additional source of income can attend the USMP SCP" (Focus group, August, 2014).

Changes in the types of funding received and their guidelines were just some of the factors impacting the evolution of the USMP SCP. As the teaching force changed in area school districts, the USMP SCP made adjustments to meet the needs of school districts.

Changes in the teaching force. Faced with the shortage of mathematics teachers, many school districts have struggled to fill empty teaching positions. Many of these spots have been filled by those lacking in mathematical and pedagogical content knowledge. According to Mr. Parker, some of the changes in the teaching force are due to the political issue that is:

> Framed on how best to provide resources to accomplish the goal of a more universal rigorous mathematics education, and then how to assess that the resources are being used effectively. The resource allocation situation affects how schools hire and retain teachers, with some schools choosing to hire newer teachers at the expense of teachers with more seniority (and thus more expense) and other schools filling difficult to fill positions with alternatively certified teachers (such as Teach for America teachers) with minimal pedagogical training. (Interview, April, 2015)

Mr. Parker stated that many of the alternatively certified teachers are "not committed to teaching as a career so the number of years that they teach has decreased. Therefore,

districts are constantly having to find new teachers" (Interview, April, 2015). Mr. Parker also noted that changes in the teaching force occurred as a result of:

> Increases in the requirements for mathematics to graduate, especially at the high school level. We have gone from where students only needed to take two mathematics courses to now where they have the four-by-four or the modifications based on House Bill 5. So you have two things going on. You've got teachers not staying in the career as long and you've got students having to take more math classes. (Interview, April, 2015)

As changes occurred in the teaching force, the USMP SCP made adjustments to meet the needs of those teachers. Dr. Gianakos recalled that in the early years of the USMP SCP:

> We brought in only the top teachers and they had to be teaching and have at least three years of experience under their belts. But then we started getting requests from principals. . . . "What about my teachers who need help? I can't always send my best. I need to send the others too." (Interview, September, 2014)

As some of the struggling teachers began enrolling in the program, the content of the USMP SCP had to transition from a focus on high-level mathematics to a focus on mathematics needed for classroom instruction. Mr. Parker remarked that:

> As our population changed to include more of those who had not gotten a formal methods course, there was a sense in that transition period when we moved to that – that we needed to provide in a sense a methods course for those teachers. A lot of our school districts were expecting their teachers to come and get instruction on how to teach the entire curriculum. (Interview, September, 2014)

One of my responsibilities as a master teacher in the USMP SCP during this transition period was to develop a curriculum that would enhance the participating teachers' mathematical knowledge for teaching. With the wide span of participants' teaching experience, this was not always an easy task. Mr. Sullivan, another master teacher during the transition years, recollected that:

> As the program went on, we had to deal with some teachers who were very, very sharp and were looking to expand their knowledge and we had to provide some upper end things for them. But we also we had some teachers at the lower end who were trying to gain proficiency and we had to spend a significant amount of time trying to upgrade their skills so they could be effective. (Focus group, August, 2014)

Lilly, one of the participating teachers in the USMP SCP, described the struggle she had as first-year teacher and her experience with the summer program:

> I realized everything I was explaining to the kids, they were just complaining. They didn't understand. . . . It was kind of frustrating because I am an engineer so I am supposed to know the math. . . . So I said okay, I need to go back to take classes on how to teach. Because even if I have the knowledge, I do not know how to communicate or anything. So I went there and everything was grand. I went there thinking I would know everything. But I went there and forget it. It was not easy at all. So I changed myself a lot. Even knowing that there are so many strategies used in this country that I never used in my country where I was coming from. I was struggling a lot, even as a student. . . . So I started realizing that I needed to keep getting more training. (Interview, October, 2014)

The USMP SCP evolved to meet the needs of the changing types of teachers attending the program. Many of these changes to the program were due to some of the participants struggling to teach the curriculum mandated by national and state standards.

Curriculum standards. Since the appearance of the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* in 1989, national standards have been established to outline the goals of mathematics education. Since the USMP SCP was established in 1987, Dr. Gianakos remarked that the "USMP SCP preceded the NCTM standards . . . and when they came out, of course, we were aligned to them because the master teachers were teaching good mathematics" (Interview, September, 2014). However once the *Curriculum and Evaluation Standards for School Mathematics* were published, they were used to guide the master teachers in planning instruction. Mr. Sullivan remembered that one of the big changes impacting mathematics education in the early years of the USMP SCP "was the new math standards. I think pretty much everyone in the program bought into those but not everyone in the math community did" (Focus group, August, 2014).

When planning the content of the USMP SCP, the other master teachers and I incorporated the use of modeling that was emphasized in standards outlined by NCTM. Deborah recalled that during her time as a participant in the USMP SCP in the early 1990's there was a movement in mathematics education to incorporate:

> Hands-on, using manipulatives to teach. We moved from all of this memorization to building concepts and building conceptual understanding in 1993 and also a big push was problem solving – process problem solving versus word problem solving; which was building student perseverance to solve a problem over time –

> do some and then come back to it. I think those were the two movements and looking at the child's growth and development as we looked at the content and what was appropriate for how we would teach a student. We used a lot of materials from activities integrating math and science. So the big thing with the USMP SCP was "okay you are doing a concrete but you have to move to the pictorial, and then from the pictorial to the abstract." . . . We talked about how we sometimes needed to let a student stay at a certain stage longer because they had not grasped or were not able to transfer the knowledge and it was okay to allow the student to develop because they would eventually transfer. (Interview, August, 2014)

Not only was the USMP SCP impacted by the national standards outlined by NCTM, the design of the program was also influenced by the state standards for mathematics education.

Taking into account the national and state curriculum standards, the USMP SCP administrators and master teachers have revised the program's curriculum to address the needs of mathematics teachers. Describing the impact of the standards on changes in the program, Mr. Parker noted that the curriculum of the USMP SCP became more focused on the content taught by teachers at their specific grade levels:

> The content had to become more applicable to their day-to-day teaching. . . . It had to change from that content for the sake of math content to content that is really needed by teachers to teach in their classrooms. (Interview, September, 2014)

As Mr. Parker described, most of the content of the USMP SCP is determined by the curriculum standards which provide the framework for the content taught by mathematics teachers. When revisions occur in the standards, the master teachers and I must modify our plans for instruction during the summer program in order to share content knowledge and activities that are appropriate to address the needs of the participating teachers.

The curriculum standards are also what motivate some teachers to participate in the USMP SCP. Lilly's decision to attend USMP SCP several times was due to the increased rigor of the curriculum standards and the added pressure to effectively teach new concepts. She explained:

> I know that the curriculum is too demanding and every time I use something it is already old or it is not enough for what they are expecting. . . . I realize that what I do or what I have is not enough – it is good, but it is not enough for what they are asking for. . . . So it makes me – it forces me to do something else. Because otherwise I am going to be struggling and it is going to be too stressful. (Interview, October, 2014)

As the master teachers prepared lessons to present novel ways of teaching the curriculum standards, they realized that emerging technology was an essential component of the USMP SCP.

Technology. The use of technology has always been an important element of the USMP SCP. As Dr. Gianakos stated, "Technology was always there from the very beginning, but technology just evolved" (Interview, September, 2014). As a participant in the second year of the program, I remember receiving a TI-65 calculator. At the time, this calculator was new technology for me and most of the participating teachers. During the

USMP SCP, lessons were given to enable us to use the calculator on our assignments and to encourage us to use calculators with our students. In an evaluation report on the use of calculators by participants during the first two years of the USMP SCP, Austin (1989) noted that the use of calculators in the program "had a positive impact on participant attitudes toward the use of calculators in mathematics education. About 91% indicated that the project has given them a more positive view of the use of calculators" (Abstract).

Dr. Gianakos discussed the impact of technology on the USMP SCP and its participants:

> Instruction changed from a handheld scientific calculator, which you learned to program, to graphing technology to learning how to use the Internet. Having email accounts, how to add attachments – teachers did not know that in the early years. What is email? All of the changes were as a result of the world-wide web – so we had to do that to keep teachers current. (Interview, September, 2014)

Mrs. Carpenter recalled how the USMP SCP was always "on the cutting edge, especially with technology. . . . It was a challenge as a master teacher to keep up with some of the technology changes and see how to integrate these into the teaching of students" (Focus group, August, 2014). As the technology evolved, the other master teachers and I spent quite a bit of time trying to become adept with using the new technology. For several years, the USMP SCP master teachers allowed time at the beginning of the program to help teachers set up email accounts. This use of technology was very new in the 1990s and only a few teachers had email accounts. Amy, a participant of the USMP SCP, laughed as she recalled that it was during the summer program "when I first got my email. We had to sign up for email in 2001" (Interview, October, 2014). The USMP SCP

master teachers also provided professional development to demonstrate to teachers how to "surf the Internet" and the advantages of using this new technology.

Deborah, a participant in the 2004 USMP SCP, remembered how technology was incorporated into the program:

> Technology was just soaring. The use of technology – because we would have a complete lab time. We had lots of software that was given to us that would emulate what we did. So we used computer technology, we used graphing technology, and we related the computer and the graphing technology to the manipulatives that we actually used in the classroom so that we could see the different platforms in which to teach. For example, we could do random numbers in many ways – by trying to generate a probability. But seeing how the graphing calculator allowed a concept to be developed. How the graphing calculator really didn't water down the math, but allowed you to do more complex math, to see patterns. So instead of sitting there looking at the computation, we were able to build tables and look at the patterns within the tables and see how the tables related to the graph. We did graphing and then we used the graphing technology. We did it by hand and then we did it with graphing technology so we were able to scaffold and then we did it on computers as well. (Interview, August, 2014)

As the different types of technology have evolved, so have the ways that technology has been incorporated into the USMP SCP. Dr. Gianakos elaborated on the current uses of technology in the program:

> It isn't just a handheld calculator, now it is a computer and a tablet and software and the Internet . . . all of the You-tube videos and all of the opportunities to see what the Internet holds for teachers. (Interview, September, 2014)

Mr. Parker agreed that the current use of technology in the program "is just more grounded in the realities of the classroom and grounded on how technology has changed society" (Interview, September, 2014).

With the advent of the university's online collaboration and course management system, the USMP SCP altered the method in which instructional resources were delivered. This virtual workspace serves as an online repository for course information, announcements, schedules, gradebook, and resources. Prior to the use of this technology, the participants would receive three-inch binders that they would fill with resources and handouts of activities done in class. With the online collaboration and course management system, the master teachers upload resources to their specific course site. Dr. Gianakos stated that this new technology "has dramatically changed the USMP SCP because now teachers have access to what they learned and what they received forever. So we have been able to put a compendium together for them and I think that is important" (Interview, September, 2014).

Additional features of this online collaboration and course management system were described by Mrs. Walters. She stated that this system has enhanced the USMP SCP:

> That program has brought it to a different level where teachers can, as long as teachers keep this account, they can go back and look at these resources. It also helped with communication. We weren't doing a lot of communication after the

> program. It used to be once the program was over, the teachers did not communicate except if they kept an email or phone number for classmates. Now they can use this system to email the whole group and let them know what they are doing, or use forum, or take a poll, or take a test. There is so much – an endless amount of what they can do. (Focus group, August, 2014)

During his interview, Brett also related how the advancement of technology has impacted the USMP SCP. As a participant in the 2008 and 2013 programs, Brett stated that:

> It is amazing that 2008 technology-wise is almost the Stone ages. I believe that we got a TI84. Calculator was the big technology that we got that time. They kind of showed us a few things. I believe we were shown a few softwares . . . I think it was GeoGebra . . . and that seemed to be sort of the emphasis there. I have been a geometry teacher for several years and thought I was good and I thought I wouldn't learn much here. But of course you do because you have all of these good teachers. I remember some books, but the main technology was the calculator at that time and then some viewing of some stuff online. . . . By the time we got to 2013, we were given an iPad mini, a laptop which I still use, and then it was the apps. You know – dozens of apps to use. . . . I use a few of them and that is when flipping the classroom was going on. It was an idea that was coming about and I decided to try to do some of those things. I tried quite a few of those, but the technology aspect was much more focused in 2013. (Interview, September, 2014)

As Brett alluded to in his interview, the USMP SCP evolved to include current technology. The administrators and master teachers of the USMP SCP understood the

importance of supporting teachers in utilizing technology in the classroom and incorporated the use of technology into lessons. Amy described some of changes in the USMP SCP and the frustrations she encountered with the rapidly-changing technology:

> Now with the technology aspect, that is where it is evolving and it is changing. I am also reading where it is – like we can bring in mobile devices and well now there are apps and now iPads and so I know – like I said that our school just dumped it on us. And the USMP SCP was including it . . . which makes sense too because I think that once the iPads came out and the iPhones came out, that it was more of an explosion which couldn't be controlled by anyone of all this opportunity and all these different ways that it wasn't just a linear, like I said – it was just a massive explosion where everybody said "Oh my gosh, we have access to all this stuff. Oh my gosh, we can include and teach all of this?" So with saying that, it's like you can't – you want to do it in steps, but the technology that was out there didn't allow for a linear growth, it just said "Here it all is." (Interview, October, 2014)

In order to encourage teachers to use technology in their classrooms, the USMP SCP master teachers provided lessons and time for the participating teachers to explore using technology. During the summer program, the participating teachers were urged to discover appropriate uses of technology in the classroom when they were given the assignment to share with classmates a website and an app that would develop students' understanding of mathematical concepts. Mrs. Carpenter also provided details of how technology was a factor in the evolution of the USMP SCP by including some of the questions addressed by the master teachers during the program:

> Another change is the iPad. That is huge in my world because a lot of schools can afford iPads and a lot of schools have them, but the question is "How do they use them?" How do you enhance instruction through the use of that technology? To have someone stand up and model that and go out and encourage them to find programs that do that and that teachers can use for small groups or their tutorials. What a gift! (Focus group, August, 2014)

Accountability. The focus on accountability has been another factor impacting the evolution of the USMP SCP. Prior to the No Child Left Behind Act (NCLB), the USMP SCP's focus was on getting participating teachers to talk about math, enjoy math, and teach math at a high level. Dr. Gianakos described some of the changes that have occurred in the USMP SCP since the national attention on high-stakes testing:

> Now, it is let's get our teachers to really know math but also the math that they have to teach to get their students to pass these high-stakes tests. So as a result, the curriculum started focusing on assessment, especially formative assessment. How do you know what kids know? How do you remediate when kids don't have what they need to perform at grade level? It is now more diagnosis, remediation, formative assessment, assessment for learning, differentiated instruction, how to deconstruct the tests so that the teachers and the students know what the test is all about. So it is more unfortunately tied to the national movement on testing. (Interview, September, 2014)

During the focus group, the USMP SCP master teachers reflected on the impact of testing on the USMP SCP. Since the changes brought about by NCTM's *Standards,* Mr. Sullivan stated that the overwhelming largest change to the USMP SCP has been due to

"standardized testing. When teachers' jobs depend on how their students perform on tests, then one of the things we have to address is how can we help your students be successful on testing" (Focus group, August, 2014).

Mrs. Walters, one of the USMP SCP master teachers, stated that while the demands of NCLB initially focused on students, now emphasis is placed on the competency of teachers. The philosophy of the USMP SCP, according to Mr. Parker, is "that if you teach good math and you teach it well, then your students will do well on the standardized test" (Interview, September, 2014). As one of the teachers participating in the 2008 and 2013 USMP SCP, Brett identified the state assessment as a major factor impacting mathematics education during his time as a participant. According to Brett, the test has driven so much and now influences teacher evaluations. Although he is usually helpful with his colleagues, Brett indicated that he probably does not share as much as he could because his evaluation is actually downgraded if his students do not show as much growth as another teacher's students. Reflecting on these concerns, Brett stated that "those are the issues I see right now with education. I don't think the USMP SCP can help fix that or solve the problem but you do give us enough enthusiasm to trudge through and do the best we can" (Interview, September, 2014).

As a result of the focus on accountability, Mr. Parker described how the USMP SCP "strives to help teachers build their self- and collective- efficacy so that they have the confidence to realize that by teaching student-centered mathematics, they will be adequately preparing students for assessments, and more importantly for future mathematics learning" (Interview, September, 2014).

Equity. The evolution of the USMP SCP has occurred as the program's administrators and master teachers try to keep current with the issues facing mathematics education. Mr. Parker described equity as one of the major factors impacting mathematics education:

> Socially I feel the biggest current issue is how to make sure more (theoretically all) students leave school with the capacity to use mathematics in a meaningful way, particularly by providing students with enough knowledge of mathematics to be able to pursue education and then jobs in an increasingly technology-dependent world. From a mathematics education standpoint, this leads to the issue of how to engage all learners in meaningful mathematics in an equitable manner in the classroom, how to assess students to know which ones need more assistance, and then how to differentiate instruction to ensure struggling students are given the appropriate opportunities to "catch up" while providing opportunities for enrichment for those students who are not struggling. (Interview, April, 2015)

According to Mr. Parker, some of the changes to the USMP SCP were based on addressing these issues. He stated that during the USMP SCP:

> We do talk about testing, but the curriculum focuses on the needs of the diverse student population. We do look at equity, more than we did at the beginning. We did not talk about equity at the beginning, but we do now. We now talk about what are the needs of your English Language Learners, what are the needs of your diverse populations. (Interview, September, 2014)

Mr. Parker described some of the specific ways in which the USMP SCP supports teachers in providing equitable education for their students:

> The USMP SCP has always, and must always be cognizant of the realities of teachers and schools. The summer campus program strives to help teachers understand how to engage all students in the learning process in meaningful, interesting ways while providing the rigor that is demonstrated by student success on academic assessments. By placing the teacher participants in the role of students as they immerse themselves in important mathematics content, and then making sure to deconstruct the activities through "teacher talk," participants in the summer campus program develop both the mathematical and pedagogical knowledge necessary to be more successful in the classroom. (Interview, April, 2015)

Mrs. Carpenter also discussed how the master teachers now make a more conscious effort of working with the participating "teachers to show them strategies that will work with English Language Learners or special education kids – especially the English Language Learners with vocabulary" (Focus group, August, 2014).

Just as the participating teachers struggle in their classrooms to provide lessons that meet the needs of all of their learners, so do the master teachers in the USMP SCP. During the first few years of the USMP SCP, lectures were the predominant form of instruction. Now, as Brett pointed out:

> Learning styles are changing – we used to just talk about visual, kinesthetic, and auditory type learners but now we still have those kinds of learners but the way they access and retain information is different now than it was years ago because

> everybody is constantly connected to the Internet now. (Interview, September, 2014)

As the other master teachers and I plan lessons for the USMP SCP, we recognize that we have to address all of these different learning styles of our participating teachers. Our lessons now include hands-on activities, videos, songs, and artwork.

Components Contributing to the Sustainability of the USMP SCP

Since its establishment in 1987, the USMP SCP has evolved through its response to factors impacting mathematics education during the last thirty years and has continued to be an enduring source of professional development for area mathematics teachers. The data analyzed for this study suggested that several aspects of the USMP SCP accounted for its sustainability. The faculty and staff, collaboration and adaptability, high-quality professional development, and communities of practice were all noted in the data as components that contributed to the sustainability of the USMP SCP.

Faculty and staff. The people involved in the USMP SCP were listed by all of the subjects of this study as essential elements in the sustainability of the program. The administrators, master teachers, and staff of the USMP SCP were all described as important components of the program.

After being involved in the USMP SCP as a participant and then as a master teacher, I realize that the sustainability of this program is dependent on all of the people involved in the program. The administrators of the USMP SCP provide the vision and secure the funds for the program. They also share their desire that all participating teachers feel like professionals. In order to achieve this mission, the faculty and staff of the USMP SCP focus on meeting the needs of each individual participating teacher.

Visiting with the participating teachers during breakfast and lunch, assisting them with developing curriculum to use in their classrooms, and encouraging them as they stretch their knowledge of mathematics are just some of the ways that the other master teachers and I develop relationships with the participating teachers.

Describing the USMP SCP as the trunk of a tree with the people as the roots, Dr. Gianakos stated that "There is a strong trunk because of a strong root system and many leaves because the tree can sustain it even under hurricane force winds like testing" (Interview, September, 2014). Dr. Gianakos elaborated on how the USMP SCP is staffed for success:

> A lot of programs put one person in a room with a thousand people and call that professional development. That is not effective. We know and recognize that there has to be that connection between the teachers who come and our teaching team – our whole team. And if teachers feel that they are just a number, they are not going to open up and really get the help they need or grow the way they want to grow. So we have always overstaffed. That is why this program is expensive. But we get the best people and then we make sure we load everything for success. Collegiality – with the food. Respect for teachers. Getting to know people personally. So I think that is important too – the people. (Interview, September, 2014)

Brett, one of the USMP SCP participants, also mentioned the people involved with the USMP SCP as an important factor in its sustainability. When asked about what sustained the USMP SCP, Brett commented:

> I think it's the human capital. All of the people associated with the program . . . you know the teachers, the support staff, the people giving us the food. Everyone seemed to enjoy working for the USMP SCP during the summer. And when you have that, then how can you possibly not want to give your best effort as a participant there? (Interview, September, 2014)

As Brett mentioned, all of the people involved in the USMP SCP made an impression on him during the program. One important factor that I have observed about the faculty and staff of the USMP SCP is that most of these individuals have been associated with the program for at least ten years. I believe that the stability of the USMP SCP personnel contributes to the success of the program because each faculty and staff member has a deep understanding of the program and its goals.

Deborah, another participant, commented that the leaders sustain the program. She remarked that the leaders of the USMP SCP are:

> Staples in maintaining high integrity in the implementation of high-quality professional development. . . . For a long time math professors were elitists and they were untouchables – but not in the USMP SCP. They are brilliant, but they listen to your thinking, they encourage you to push yourself. It is the relationships that are formed with the leadership. (Interview, August, 2014)

The leadership of the USMP SCP starts with a leader. As Mrs. Walters stated, a program cannot sustain itself without "a great director with a vision" (Focus group, August, 2014). Dr. Gianakos, the current director of the USMP SCP, has been involved with the USMP SCP since its inception. According to Mr. Sullivan, Dr. Gianakos is "very talented at seeking out resources from the community and national and this program would not have

had the success that it has if we did not have some quality people supervising that end of it" (Focus group, August, 2014).

According to Mrs. Carpenter, "Teachers teaching teachers has been one of the key things" in ensuring the sustainability of the USMP SCP (Focus group, August, 2014). As a member of the USMP SCP team for over twenty-five years, I have been able to work with some extraordinary master teachers who demonstrated their passion for providing high-quality professional development in order to enhance the mathematics knowledge of teachers and students. In describing the contribution of master teachers to the sustainability of the program, Mr. Parker stated that:

> The master teacher model is different than some other programs where it is just university professors providing instruction for teachers. I think the fact that our master teachers are classroom teachers that are authentic that have that validity – that can develop that trust relationship with the participants in the class. . . . Now does that mean that every master teacher that has been in the program for the last 29 years has been wonderful? No – just like every program, we have some who are not as effective as others and some that don't fit as well as others and we have to make adjustments from year to year. So I think it is the people on this staff, but it is also the master teachers who provide the day to day instruction. The majority of them are products of our program. They have been through the program so in a sense we grow our own in a lot of ways. So I think they are a huge part of it as well. (Interview, September, 2014)

Agreeing that the idea of employing teachers to teach teachers was an important factor in the USMP SCP's sustainability, Mr. Sullivan commented on how the participants view their experiences in a program taught by teachers:

> It makes a difference when they know that their master teachers are also in classrooms dealing with the same issues that they are. It is not like a college of education where you have professors talking about what is in the classroom when they really don't know. The master teachers are getting their feet wet in the same way as the other teachers and can sympathize with their problems. (Focus group, August, 2014)

Mr. Sullivan also suggested that "one strength of the USMP SCP is the interplay and coordination of the master teachers in the program together with the program leaders" (Focus group, August, 2014). Mrs. Carpenter identified the support provided by Dr. Gianakos to master teachers as being essential to the program's sustainability:

> And again it is back to that cutting edge. Dr. Gianakos was out there . . . finding good solid instruction and training the master teachers. We then turned around and trained thousands of other teachers on that. I think it is a brilliant plan as long as you've got, like you said, that person at the top – to be a person with vision. If there is anything that Dr. Gianakos cares about – it has got to be that the mathematics be correct. Having someone with such expertise and high standards leading the group set the bar very high for all of the master teachers and for the entire staff. (Focus group, August, 2014)

Collaboration and adaptability. Collaboration with others in the mathematics community and adaptability were also identified as key components contributing to the sustainability of the USMP SCP. According to Dr. Gianakos:

> I think the reason that the USMP SCP has been sustained for this length of time is our response to the community and the outstanding people willing to do the work. All of us have been successful pre-college teachers. We know our content. We know how to teach it. We are well connected in the community and as a result we are trusted by the school districts to help them by preparing their teachers. (Interview, September, 2014)

Dr. Gianakos also recalled that in the late 1980s, the USMP SCP "was just a program for teachers – from the university to teachers. Now it is a collaboration" (Interview, September, 2014). The university values the accomplishments of the USMP and the long-term relationships built with the community and awards graduate credit to the participants of the USMP SCP as a result of the grants that USMP is awarded to do the work. Dr. Gianakos noted that other universities and surrounding school districts recognized the USMP SCP for its excellence, rigor, and high expectations and other universities accepted the graduate credit in their own programs.

Mr. Parker, an administrator for the USMP SCP, asserted that by collaborating with local schools and districts, the USMP SCP has been able to understand the needs of mathematics teachers and has been able to adapt its curriculum to meet the changing needs of the participating teachers. According to Mr. Parker, adaptability must be "coupled with maintaining high standards and expectations. It has to be both. You can

adapt and lose your focus and your quality. I think it is maintaining the high standards coupled with adaptability" (Interview, September, 2014).

Dr. Gianakos acknowledged that collaboration and adaptability were key components for sustainability:

> We realized we could not be teaching linear algebra, probability and statistics today the way we did in year one and year two. We realized that would not sustain USMP so we really looked at what could we do to help the community in which we live. We live in an urban setting. What can the USMP and the USMP SCP do to help our neighbors? So all of the changes that we made were really in collaboration with school district partners to try to make the profession better meet the needs of society and I think the fact that we were willing to change is the main factor. (Interview, September, 2014)

Deborah, one of the USMP SCP participants, pointed out that the USMP heeds "what districts and teachers need when developing programs. They integrate the needs with their knowledge of what is happening in the world and how mathematics instruction is evolving to provide their clients with the content that is needed" (Interview, August, 2014).

Describing how the USMP SCP tailored its instruction to meet the needs of the mathematics community, Deborah stated that the USMP SCP was:

> Designed in a way that it met the needs of where mathematics was going so that teachers were actually on a cutting edge when they went back to their schools. They knew they were a year or even two years ahead. . . . We were already being trained on the materials and the methods of thinking and even a purpose for why

> we were learning what we were learning in the classroom [and that] was based on what was happening politically and socially. . . . So USMP was always looking ahead – always looking ahead and preparing based on the social issues. So the program designed itself to prepare for the social and political changes. (Interview, August, 2014)

Mr. Parker affirmed that the USMP SCP curriculum continues to change as the administrators collaborate with districts and address the needs of teachers and students:

> We become more focused on what is going on in the classroom. Even though math is still the huge focus, we are doing more integration with other subjects, particularly art. We also include reading, literature, science, and social studies when it is appropriate. The reality of the classroom is that math is not always taught in isolation and I think our curriculum is evolving to reflect that as time goes on. (Interview, September, 2014)

High-quality professional development. After adapting the curriculum to meet the needs of the mathematics community, the USMP SCP provides an opportunity for mathematics teachers to receive professional development. Dr. Gianakos stated that as the USMP SCP was being designed, the mathematics director for an area school district asked her to:

> Package as much as you can for teachers because they are pulled in a million directions so get that TAGT [Texas Association for the Gifted and Talented] credit. Get that CPE [Continuing Professional Education] credit. Do everything you can do to help teachers because they are being beaten up from all directions

> and they have to have credentials. If there is one program that can do it all for them comprehensively, then do that. (Interview, September, 2014)

The resulting high-quality professional development provided by the USMP SCP is another component leading to the sustainability of the program. Mrs. Walters stated that schools recognize that the USMP SCP provides "high-quality professional development that is going to give the teachers the knowledge to get the critical thinking that the students need in order to move those students from where they are to where they need to be" (Focus group, August, 2014). As a participant, Brett stated that "It would be super easy to cover material for the year, but I feel like I try to uncover material and the USMP SCP gives you tools, techniques, ideas to do that" (Interview, September, 2014).

Dr. Gianakos stated that the USMP SCP was designed to allow "teachers to construct their knowledge as learners so that they would know what it took for kids to construct their knowledge as learners. We did not want an open hole in the brain to pour in math" (Interview, September, 2014). Mr. Parker also mentioned that modeling was important as "was the teacher talk and being more explicit about why we are doing the things that we are doing and why we are asking the questions we are asking" (Interview, September, 2014). Amy revealed that this modeling of effective teaching throughout the USMP SCP built up her confidence as a mathematics teacher:

> The whole program just opened me up into saying or kind of building up my confidence into saying – no, I do know the math. I do know that I need to teach to where I am more of a guidance or a facilitator and not necessarily to say – oh, just do it this way because then we take it away from the students and we start doing all the work. . . . You develop a toolbox or your lesson plans which is great, but

> what it allows you to do better is think more effectively and more efficiently and also teach, for a lack of a better phrase, to teach better and teach less, but to teach deeper too where you give control back to the student because you can listen effectively and because again you were a student and you went through it and you walked through it and you were able to step out of it and reflect and look back on it and say okay what happened here as a teacher? (Interview, October, 2014)

Lorraine, another participant of the USMP SCP, also agreed that the USMP SCP increased her own knowledge of mathematics. She "liked the approach of asking questions – not telling – asking open-ended questions" (Interview, October, 2014). Lilly, another participant of the USMP SCP, appreciated the manner in which the master teachers explained the same concept in multiple ways. After seeing the benefit of using various strategies to teach a mathematics concept, Lilly stated that now when teaching in her own classroom "I also find myself doing this because sometimes I feel that since English is not my first language I don't get it the way most people get it" (Interview, October, 2014).

One characteristic of the professional development provided by the USMP SCP that Deborah appreciated was the encouragement she received:

> One of the wonderful things about going through the USMP SCP is that you are never made to feel bad about what you don't know about math. Like math courses will make you feel very intimidated or feel insecure about your math content knowledge, but the USMP SCP does not do that. The USMP SCP just builds on it and encourages the teacher both in the math content and also in math pedagogy. So when I taught my students, I think that carried over as my students never felt

> intimidated about what they didn't know and I just kept encouraging them. (Interview, August, 2014)

Another participant, Amy, described the professional development provided in the USMP SCP as never being out of date due to the planning of the administrators and teachers of the program:

> They really look at the math education of students – of what is expected of them at every grade level and they dig deeper. And I think when they do that, whether we evolve with a state mandated test, you know like STAAR [State of Texas Assessments of Academic Readiness] or No Child Left Behind – it is such good quality – that it is a test of time. It can't be outdated. (Interview, October, 2014)

According to Lorraine, the professional development provided by the USMP SCP remains high-quality because the pedagogy used in the USMP SCP is "research-based and feedback regarding the program is solicited" (Interview, October, 2014) which allows the program to develop and not remain stagnant. Regarding feedback, Mrs. Walters stated that having the participants provide feedback was an important component of continuing to provide high-quality professional development. She remarked that when the USMP "started the survey and saw what the teachers' needs were . . . we changed those things. . . . I think that has really been the key" (Focus group, August, 2014). After completing the USMP SCP, the participants provide feedback. As Mrs. Walters mentioned, the administrators and master teachers use the feedback provided to evaluate the program and make adjustments to improve the program in order to continue providing high-quality professional development that meets the needs of the mathematics teachers and their school districts.

Communities of practice. The relationships I formed with other members of the mathematics community are the most valuable things I gained during my experiences as a participant and a master teacher for the USMP SCP. The data collected for this study showed that many others had the same perception.

Mr. Parker described three communities of practice in which the participating teachers of the USMP SCP have membership. The first group is the classroom community of practice in which the participating teachers "have the shared curriculum and the shared experiences because they are doing the same thing" (Interview, April, 2015). The second group is the community of practice in which the participating teachers share the summer community of experience by attending colloquia and book studies with teachers from all grade bands. The third group is the community of practice in which participants of all years of the USMP SCP band together to attend networking conferences or share ideas.

One of the master teachers, Mr. Sullivan, observed that teaching is a stressful job and that the USMP SCP was able to reinstill enthusiasm for the teachers attending the program and perhaps prevented some teachers from leaving the profession. By participating in the USMP SCP, participants realize that they do not have to face their struggles alone. Mr. Sullivan stated that the participants begin to understand that there "are other people in their class who are dealing with the same issues they are dealing with and they can share in their conversation and get ideas from each other and support each other" (Focus group, August, 2014). Mr. Sullivan explained that when participants attend a program like the USMP SCP, they realize that they are not isolated anymore because there are other people dealing with similar issues.

Amy explained that the sharing of ideas among the USMP SCP participants enhanced her teaching:

> You have to be open-minded to different ways that kids learn and different strategies that they come up with. And I think as a teacher that that open-mindedness is good but we have to be able to understand it too. And with that, I liked the fact that we communicated and everybody shared their ideas and said well I thought of it this way and it opened you up – Oh I never thought of it like that before. It made me listen to my students better and also kind of made me in a way more of a guidance and kind of a little bit of a translator because as adults we have the fortune of understanding and being able to listen to other kids and understand different concepts whereas students they sometimes know one way and when another student tries to explain it – they are like, I don't get that. Whereas, you know being a teacher, I can kind of explain it and you know to where I said "Oh no, no – this is how you guys are similar and stuff." So I was appreciative of that. (Interview, October, 2014)

Lilly described working with good teachers who wanted to get better as a strong point of the USMP SCP. She also commented on the importance of working with other mathematics teachers by stating that society demands that people "work together to figure things out. So if we can provide that in mathematics – you know students working with partners or maybe as a group of four. Again that is a skill that they will take with them" (Interview, October, 2014). Lilly described the advantages of working with teams to develop communities of practice by stating that "in dialogue and in talking to someone else sometimes you come up with a new idea or you get clarification and think 'No, that

idea is really better' so you had more resources for lack of a better word" (Interview, October, 2014).

The networking conferences are held twice a year as part of the USMP SCP. Developing communities of practice through the networking conferences was described by Mr. Parker as a key component in promoting the sustainability of the USMP SCP:

> To me, the networking conference is really the connective tissue across all of the groups who have attended the USMP SCP. It may be cliché to talk about communities of practice. But I always see the networking conferences as the communities of practice for all of the teachers who have attended during past USMP SCP. The networking conferences are really communities of practice and that is what allows each summer not to stand alone, but it is part of a huge 29 year community of teachers. (Interview, September, 2014)

Mr. Parker elaborated on how these communities of practice are developed throughout the USMP SCP:

> Through the activities of the summer, follow-up activities, and activities such as our networking conference that bring together past participants from the past 30 years of the program, participants become part of the USMP family. Participants always feel comfortable contacting master teachers and directors for support and advice and are also welcoming and supportive of new members of the USMP family. Without these strong relationships I do not feel that the program would have sustained itself for as long as it has. (Interview, September, 2014)

Summary

The results presented above describe the participants of this study, the evolution of the USMP SCP, the factors that impacted the evolution of the USMP SCP, and the components of the USMP SCP that contribute to the program's sustainability. A more detailed summary and a discussion of the findings are presented in the next chapter.

Chapter V

Summary, Discussion, and Reflection

> *The formulation of educational knowledge – what is important to know and what should or should not be reflected in the study and practice of education – has historically been a consequence of social and political as well as academic developments.* (Novoa & Yariv-Mashal, 2003, pp. 423-424)

This study focused on a university/school collaboration that provides professional development for mathematics teachers. This final chapter of my dissertation reiterates my research questions and reviews the methodology used in this study to examine the evolution of a university summer campus program for mathematics teachers. A summary and discussion of the results of my study and a reflection on my research are also included in this chapter.

Statement of the problem

During the last century, the mathematics education of students in America has been impacted by concerns about national security, the economy, and social justice. Mathematics teachers are challenged to transform their teaching to prepare all students for a quickly developing global workplace that "demands more quantitative and scientific knowledge and calls for workers who can think creatively, work together, and solve complex problems that don't yet exist" (Seeley, 2009, p. 172). As new knowledge, tools, and ways of doing and communicating mathematics continue to emerge and evolve, teachers must be prepared to provide their students with opportunities and the support necessary to learn significant mathematics with depth and understanding.

Policy makers and school leaders understand that "a great teacher can make the difference between a student who achieves at high levels and a student who slips through the cracks" (USDE, 2010, p.13) and recognize that high-quality professional development is essential to effectively equip teachers with the mathematical knowledge for teaching that is required to meet the needs of all students. To address the demands for systemic reform in education and provide professional development for mathematics teachers, university summer campus programs have been developed through university/school collaborations.

As changes in local, state, and national educational policies occur, university summer campus programs have to adapt to these changes in order to meet the needs of their participants. Although the need for professional development has been documented, there is a gap in the knowledge of how university summer campus programs providing professional development for mathematics teachers have evolved to address the social and political demands of the nation. The purpose of this study was to investigate the following research questions.

1. How did the University School Mathematics Project's Summer Campus Program for K-12 mathematics teachers evolve to meet the demands of mathematics reform?
2. What factors, including social and political factors, have impacted the evolution of the University School Mathematics Project's Summer Campus Program?
3. What components of the University School Mathematics Project's Summer Campus Program have contributed to the sustainability of the university summer campus program for K-12 mathematics teachers?

Data from a variety of sources including archival data, descriptive surveys, a focus group, and interviews were used to answer these questions

Review of the methodology

This study focused on the University School Mathematics Project (USMP) which was established in 1987 as a bridge between the mathematics research community and mathematics teachers. The USMP provides professional development to area mathematics teachers through its summer campus program (USMP SCP). The recognition of the USMP SCP as a model program by the National Staff Development Council and other organizations, the frequent replication of the USMP SCP, and "its tenure provide evidence of the success and value of the University School Mathematics Project" (Killion, 2002, p. 85). These factors contributed to the selection of the USMP SCP as the ideal university summer campus program to focus on in this research study. A qualitative research design that incorporated components of case study, narrative, and historical research was utilized to study the evolution of the USMP SCP from 1987 to 2015. In order to collect data for this study, I retrieved historical documentation, administered descriptive surveys, and conducted a focus group and interviews.

Investigating the evolution of the USMP SCP required that I use purposive sampling to obtain information from participants of the USMP SCP and from those who were involved in the planning and/or implementing of the USMP SCP during different periods of time. The three specific populations that I targeted to provide essential information for this study included administrators, master teachers, and participants of the USMP SCP. Based on their unique views of the USMP SCP, the members of these targeted groups provided rich details about their experiences with the program.

Summary of the results

The USMP SCP was established in 1987 with funding provided by the National Science Foundation through its Teacher Enhancement Program. The funds were to be used to enhance the mathematical knowledge of teachers through an alliance between the university and the surrounding school communities. Although many of the original USMP SCP goals, such as increasing the mathematical knowledge of teachers and promoting communication and collaboration among and between classroom mathematics teachers and university mathematicians and statisticians, have remained important components of the program; the USMP SCP has undergone modifications to address the needs of mathematics teachers and their students.

The first USMP SCP was a six-week program for 48 middle and high school teachers who had been identified as potential lead teachers. The original design of the USMP SCP included lecture workshops, seminars, colloquia, and teaching units. During the lecture workshops, the participating teachers received instruction in high-level mathematics which included linear algebra, algebraic systems, functions, number theory, mathematical induction, and numerical methods. The instruction the participants received enhanced their mathematical knowledge, but for the majority of participants the content was not appropriate to incorporate into their classrooms. The seminars were self-directed as participants selected one of six seminar sessions that were offered, decided on a specific topic to study, and then presented lessons to the other participants in their seminars. Colloquia were included in the program as a means to connect participants with university faculty and prominent mathematics educators. During the six-week program,

the participants were also expected to create teaching units that they could use with their students.

In its almost thirty years of existence, the USMP SCP has undergone substantial changes since that initial summer program. Although colloquia, the use of master teachers as instructors for the USMP SCP, the participants' development of classroom resources, and networking conferences are still important elements of the USMP SCP, other aspects of the program have evolved to address the needs of area teachers and their students. The USMP SCP has now expanded to include mathematics teachers for grades ranging from kindergarten through high school. Currently during each summer program, 80 participating teachers receive mathematics instruction that is relevant to their specific grade band. With a focus on enhancing participating teachers' mathematical knowledge for teaching, the master teachers for the program incorporate the use of technology, manipulatives, and other resources to provide professional development.

The evolution of the USMP SCP has been impacted by several factors including financial support, changes in the teaching force, curriculum standards, technology, accountability, and equity. The primary funds for the USMP SCP are received from grants. Therefore, it is essential that the program adheres to funding guidelines. During that first summer of the USMP SCP, the program was designed for secondary teachers who were viewed as potential lead teachers. As surrounding school communities struggled with a shortage of mathematics teachers, the USMP SCP evolved into a program that would enhance the mathematical knowledge for teaching of K-12 teachers.

As national and state curriculum standards were initiated, the USMP SCP incorporated these standards into the program's curriculum. Changes in technology have

also impacted the evolution of the USMP SCP. The technology used by master teachers and participants in the program has evolved from only using a scientific calculator as the primary source of technology in 1987 to currently using interactive whiteboards, laptops, netbooks, and graphing calculators during the program to enhance learning. With the national focus on accountability and equity, the USMP SCP has evolved to include conversations on assessments and on addressing the needs of all students.

As the USMP SCP has responded to factors impacting mathematics education, it has continued to be an enduring source of professional development for area mathematics teachers. Several aspects of the USMP SCP were found to contribute to its sustainability. These components include the faculty and staff, collaboration and adaptability, high-quality professional development, and communities of practice.

Discussion of the results

This study was about the evolution of a university summer campus program for mathematics teachers. According to Avalos (2011):

> There is a constant need to study, experiment, discuss and reflect in dealing with teacher professional development on the interacting links and influences of the history and traditions of groups of teachers, the educational needs of their student populations, the expectations of their educational systems, teachers' working conditions and the opportunities to learn that are open to them. (p. 10)

This study responded to this need to study and reflect on the influences impacting teacher professional development by studying the changes that have occurred in the USMP SCP since it was established in 1987. Even though the results of this study pertained to one

specific university summer campus program, the findings were consistent with other research studies.

Evolution. The USMP SCP evolved from a six-week summer campus program with a focus on teaching higher-level mathematics to secondary mathematics teachers into a three-week summer campus program with academic follow-up that provides professional development on mathematical knowledge for teaching to improve teacher effectiveness and to increase the number of highly-qualified K-12 mathematics teachers. As Stronach and McNamara (2002) suggested, a real educational partnership is "never a stable or final achievement, always a work in progress" (p. 155). In order for a professional development program to be implemented effectively, adaptations are often necessary to address the needs of the participants. However, the overall intent of the program may be lost if too many revisions are generated. Borko (2004) suggested that "studies must investigate the balances and tradeoffs between fidelity and adaptation, and consider which elements of a program must be preserved to ensure the integrity of its underlying goals and principles" (p. 13).

During this research study, I found that the design of the USMP SCP followed the guidelines suggested by Borko. Although changes were made to the USMP SCP in response to the needs of the area school districts and their teachers, the goals of the program remained constant. These goals included enhancing the mathematical knowledge of teachers in order to broaden their mathematical understanding and to have a positive impact on their classroom interactions with students (Wells, 1986, Technical Abstract). Fullan (2007) also described the dilemmas that must be contemplated when considering educational change:

> On the one hand, we need to keep in mind the values and goals and the consequences associated with specific educational changes; and on the other hand, we need to comprehend the dynamics of educational change as a sociopolitical process involving all kinds of individual, classroom, school, local, regional, and national factors at work in interactive ways. (p. 9)

The next section will include discussions about the factors that brought about changes in the USMP SCP.

Factors. During this study, I found that the evolution of the USMP SCP was impacted by several factors. These factors included financial support, changes in the teaching force, curriculum standards, technology, accountability, and equity.

Financial support. From the data collected for this study, I was able to identify financial support as an important factor impacting the evolution of the USMP SCP. The USMP SCP was originally established through funding that was a response to concerns about challenges to our nation's economy and security and the perceived poor achievement of our nation's students in mathematics and science. These educational funds were seen as investments in America's future, and it was anticipated that these funds would improve the quality of education by enhancing the mathematical knowledge of teachers.

Bartholomew and Sandholtz (2009) also found that funding was essential to launching and institutionalizing university/school partnerships. However, they also noted that "potential conflicts related to funding extend beyond the actual monetary support. For example, when partners or outside agencies contribute funds, specific requirements or expectations may be attached" (p. 156). Dr. Gianakos made similar comments when

discussing the evolution of the USMP SCP. She stated that "there are more federal requirements for funds that require results" (Interview, September, 2014).

McCaughtry, Krause, McAuliffe, Miotke, and Price (2012) also identified financial support as a key feature that led to a successful university/school partnership:

> The partnership flourished because of the willingness of both parties to collaborate on external funding proposals, to use the expertise of university faculty who had support and expectations for external funding, and to spend external funds to accomplish the dual objectives of curriculum reform in the district and research at the university. What the district and the university have subsequently recognized is that when funds and expertise can be united to produce successful and mutually beneficial outcomes, new and unexpected opportunities for support often emerge. (p. 31)

However as Mockler (2013) found in her study of university/school partnerships, funded projects can be double-edged swords with financial support contingent on following a pre-ordained focus and implementation requirements that do not always match the issues and concerns of the local school community. Highlighting both large- and small-scale examples, Mockler stated:

> While it is not impossible for partnerships that develop in this environment to transcend the project itself, a focus on local concerns and issues such that the requirements of both the project and the local school community are met requires a level of creativity in both school- and university-based members of the partnership. Furthermore, using the funded project as a 'jumping off point' for

> partnerships that might be sustained over the long term can be fruitful: many a generative long-term partnership was begun under these conditions. (p. 286)

These findings suggest that funding is essential to achieve the goals of university/school partnerships. The ability of these partners to make adjustments based on increases or decreases in funding for their programs and adapt to the changing requirements for the financial support of these programs does impact the growth and success of university/school partnerships.

Changes in the teaching force. Another factor that I identified as impacting the evolution of the USMP SCP was the change in the teaching force. The original group of USMP SCP participants, with an average of 11 years of teaching experience, was comprised mainly of experienced mathematics teachers with the potential of becoming mathematical leaders for their schools. Although the most recent group of USMP SCP participants had an average of 6 years of teaching experience, 41.3 % of the participating teachers had 0-1 year of teaching experience. The USMP SCP evolved from a program designed for potential mathematical leaders into a professional development program for participating teachers who are predominantly classified as being not highly qualified, as defined by the No Child Left Behind Act.

Findings from a research project conducted by Ingersoll and Merrill (2012) confirm that the teaching force has indeed changed within the last few decades. Between 1987 and 2008, the number of teachers employed in schools increased by 48%. As the teaching force ballooned, a significant number of these positions were filled by inexperienced beginning teachers. The number of first-year teachers in 1987-1988 was 65,000 as compared to over 200,000 beginning teachers in 2007-2008. In the 1987-1988

academic-school year, 15 years was the most common number of years of teaching experience for a public school teacher. However in the 2007-2008 academic-school year, the most common number of years of teaching experience for a public school teacher was one year.

Changes in the teaching force have also been impacted by the high rate of teacher turnover. Ingersoll and Merrill (2012) found that beginning teachers had the highest rate of turnover:

> Members of the largest group within the largest occupation in the nation have been leaving at relatively high rates, and these rates have steadily increased in recent decades. Together, ballooning and turnover indicate a growing flux and instability in the teaching occupation, as both the number of those entering teaching and the number of those leaving teaching have been increasing in recent years. (p. 19)

As concern grows over the number of inexperienced beginning teachers, there are also concerns about the academic ability of teachers. "Not only do teachers tend to have below-average academic test scores, some researchers and commentators maintain that the academic ability of teachers has been declining over time" (Ingersoll & Merrill, 2012, p. 15).

During his interview, Mr. Parker described how an increase in number of mathematics courses required for high school graduation led to changes in the teaching force. Ingersoll and Merrill (2012) reported that changes in high-school requirements for mathematics appeared to be a major factor for the increase in the number of mathematics teachers. As students were required to take more mathematics courses, the number of

students enrolled in mathematics classes increased by 69%. This increase in students attending mathematics classes led to a demand for additional teachers who were qualified to teach these courses.

The implications of the findings from these studies and my research are that university/school partnerships must be aware of the changes in the teaching force and must be willing to make changes in the professional development offered through university summer campus in order to best meet the needs of the participating teachers.

Curriculum standards. Data that I collected for this study revealed that national and state standards for curriculum were additional factors that contributed to the evolution of the USMP SCP. As the standards changed, the curriculum of the USMP SCP was revised to ensure that the participating teachers would have opportunities to engage in activities that would develop their understanding of the new standards.

Since the release of *A Nation at Risk* in 1983, national attention has been focused on standards-based reform. Paik et al. (2011) support the alignment of professional development with curriculum standards. They recognize that since "teachers are the most important implementers of standards-based reform, professional development is a central vehicle to accomplish the intentions of reform" (p. 422). In order for teachers to put new curriculum standards into practice effectively, learning opportunities are necessary to help them become aware of the standards. Paik et al. (2011) suggested that:

> Policy makers and PD [professional development] providers should take into account teachers' actual needs to align teaching with state curriculum standards in addition to the intended outcomes by PD programs. It is also important to note that teachers need deep content understanding and applicable activities to teach

> within state curriculum standards and applicable activities to teach within state curriculum standards, rather than a basic overview, and this helps PD providers when planning or designing a PD program. (pp. 431-432)

These statements confirm the finding of this study that curriculum standards are important factors in developing the professional development component of university/school partnerships. As changes in the curriculum standards occur at the national, state, or local levels, university summer campus programs must evolve to address these revisions.

Technology. Within the past two decades, the use of technology in education has exploded. The participants of this study recognized that technology was a contributing factor to the evolution of the USMP SCP. Technology has always been incorporated into the USMP SCP. However the type and purpose of the technology has changed from the beginning of the program when scientific calculators were used for computational skills to the present-day program where laptops, netbooks, and interactive whiteboards are essential resources that are utilized to facilitate learning, to design and evaluate learning experiences, and to collaborate.

Walker et al. (2012) recognized that "the rapid growth in the creation and use of open-access online learning resources and media in education supports a transformative vision of education, one that can be more engaging and effective than current approaches" (p. 422). Resources provided by current technology can be incorporated to tailor lessons for increasingly diverse classrooms. However, "teachers vary in their technology integration knowledge, as well as in their ability to design pedagogically sound activities. As such, one documented approach for improving teachers' technology

integration skills, knowledge, and attitudes is via teacher professional development" (Walker et al., 2012, p. 422).

The finding of technology as a factor contributing to the evolution of the USMP SCP has implications for other university summer campus programs. As the use of technology in education rapidly changes, university summer campus programs for mathematics teachers must evolve to incorporate and demonstrate the appropriate use of new technology. In this technology-rich era, mathematics teachers need opportunities to explore the effective use of technology for learning and teaching.

Accountability. The results of this study also indicated that the national focus on accountability impacted the evolution of the USMP SCP. During her interview for this study, Dr. Gianakos reported that as a result of the emphasis on high-stakes testing, the curriculum of the USMP SCP evolved to include conversations on assessments, remediation, and differentiated learning. Bartholomew and Sandholtz (2009) also described accountability as a factor impacting university/school partnerships:

> High stakes testing and accountability measures have created a reform context where the policy environment is tightly coupled to instructional practice. As a result, school teachers and administrators value staff development products and strategies that reduce uncertainty for teachers and ensure that formal curriculum is 'covered' in alignment with high stakes policies. (p. 164)

Bartholomew and Sandholtz again stressed the relevance of addressing accountability when they suggested that "partners who see accountability measures as problematic to their work must find ways to recast institutional common ground in order to expand views of the teacher's role in reform" (p. 164). Without recognizing the importance of

accountability, the methods and perspectives of the university/school partnership "run the risk of being seen as irrelevant, or worse, running counter to K-12 aims and thus compromising the potential of partnerships to create learning communities that are grounded in the complexity and creativity of teachers' work" (Bartholomew & Sandholtz, 2009, p. 164).

According to Hochberg and Desimone (2010), "two critical mechanisms of professional development – especially in an accountability context that demands a rapid response and new solutions to achievement deficits – are the improvement of teachers' knowledge and the fostering of beliefs that are consistent with reform initiatives" (p. 91). As these findings suggest, the professional development components of university/school partnerships must evolve to address the key challenges posed by accountability policies.

Equity. The participants of this study identified equity as a contributing factor to the evolution of the USMP SCP. During his interview, Mr. Parker emphasized the importance of equity: "Socially I feel the biggest current issue is how to make sure more (theoretically all) students leave school with the capacity to use mathematics in a meaningful way" (Interview, April, 2015).

According to Loucks-Horsley et al. (2003), "ensuring equity in a diverse society has become extremely important as science and mathematics reform has shifted from producing a relatively few highly skilled scientist and mathematicians to promoting literacy in these disciplines for all citizens" (p. 86). Hochberg and Desimone (2010) elaborated on the influence of equity in education by reporting that "standards and accountability have dominated the education policy arena over the past two decades, as policymakers and educators have worked to reduce academic performance disparities

among racial and ethnic groups and to raise student achievement" (p. 89). In order to tackle the challenges of elevating the achievement levels of diverse learners, professional development must expand "teachers' knowledge of both content and pedagogy in a manner that considers the backgrounds and instructional and social-emotional needs of the particular students to be taught" (Hochberg & Desimone, 2010, p. 93).

American classrooms today are comprised of a diverse population of students including those with different learning styles, disabilities, special learning needs, and limited English proficiency (Hochberg & Desimone, 2010). These findings suggest that the professional development components of university/school partnerships must recognize the importance of equity and revise their programs to adequately prepare participating teachers to support academic proficiency for all learners.

Sustainability. Identifying the components that contribute to sustainability of university summer campus programs is important to those who design and fund these programs. Bartholomew and Sandholtz (2009) noted that "although school-university collaboration offers significant benefits, the task of establishing and sustaining successful partnerships is challenging" (p. 156). Several components contributing to the sustainability of the USMP SCP were identified in this study. These components included faculty and staff, collaboration and adaptability, high-quality professional development, and communities of practice.

Faculty and staff. All of the people whom I interviewed for this study cited the faculty and staff of the USMP SCP as a major component contributing to the sustainability of the program. This finding that the faculty and staff are vital to the

success and sustainability of a program is supported by Schreirer's (2005) study of program sustainability:

> The importance of leadership and staffing was shown by the fact that more than three fourths of the studies that examined influences on sustainability cited the importance of a champion, someone who is strategically placed with an organization to advocate effectively for the program. (p. 340)

Similar findings were reported by Groth (2012) in his study of professional development that included a lesson study project that involved university faculty and secondary mathematics teachers. His findings suggested that relationships between university faculty and teachers were factors that influenced the sustainability of the project.

These findings imply that the faculty and staff are important components that contribute to the sustainability of university summer campus programs. The interactions among the faculty, staff, and participating teachers can greatly influence the success of a program. The implication of these findings for university summer program developers is that the faculty and staff of these programs should make a commitment to treating participants as professionals and developing relationships that support participating teachers as they engage in professional development to enhance their knowledge of mathematics.

Collaboration and adaptability. The finding of this study that collaboration and adaptability are important components for sustaining a university summer campus program is consistent with the findings of several studies. The importance of collaboration was highlighted by Bartholomew and Sandholtz (2009):

> Collaborative efforts between schools and universities hold the potential to enhance the professional development of teachers and the educational opportunities of students. However, school-university partnerships inevitably encounter conflicts that arise from the process of linking different institutions in collaborative work. (p. 163)

In order for a university/school partnership to be sustainable, all partners must be willing to collaborate and make changes. During her interview for this study, Dr. Gianakos acknowledged that the sustainability of the USMP SCP was due in part to collaborating with area school district partners and being willing to make changes in the program to address their needs.

The significance of collaboration and adaptability was also reported by Borthwick, Stirling, Nauman, and Cook (2003). When describing elements necessary for successful university/school partnerships, one group of individuals in their study "emphasized school-university partnerships as a dynamic process that requires reexamining and changing goals as well as adapting to changing conditions" (p. 350).

This study along with similar findings from other studies suggests that collaboration and adaptability are key components for sustaining university summer campus programs. Universities and area school districts should form strategic alliances to identify shared goals, work together to determine the significant elements that should be included in professional development programs that would benefit mathematics teachers, and be willing to make modifications in the programs to address the needs of the participating mathematics teachers.

High-quality professional development. According to the data collected in this study, the USMP SCP has been sustained because of the high-quality professional development it provides. Mrs. Walters, one of the USMP SCP master teachers, emphasized that area schools recognize that the program's high-quality professional development provides opportunities for participating teachers to gain effective instructional strategies.

Research by Kruger, Davies, Eckersley, Newell, and Cherednichenko (2009) found that evidence of effective and sustainable university/school partnerships include:

> A focus on learning which is sustained by the participants contributing their personal and professional knowledge, understanding and expertise; altered relationship practices which are sustained by communication about shared concerns; [and] new enabling structures which are sustained by institutional resources. (p. 16)

A focus on authentic classroom concerns, a connection to school priorities, opportunities for reflection, discussions about assessment, and respect for each of the participants in the partnership are just a few of the specific components listed by Kruger et al. (2009) for effective and sustainable university/school partnerships. The components listed by Kruger and his associates as contributing to effective and sustainable university/school partnerships describe attributes of high-quality professional development and are implemented within the USMP SCP.

These findings suggest that high-quality professional development is an important component for the sustainability of university summer campus programs. Since teachers frequently teach as they have been taught, developers of university summer campus

programs should ensure that they incorporate characteristics of high-quality professional development which include opportunities for teachers to engage in active learning, to focus deeply on fewer ideas, and to learn collaboratively (Loucks-Horsley et al., 2003).

Communities of practice. Participants of this study identified communities of practice as one of the components of the USMP SCP that contributed to its sustainability. Consistent with this finding, Crawford, Roberts, and Hickmann (2008) also identified professional communities as an important factor in authentic university/school partnerships for professional development. They indicated that participants of university/school partnerships receive both professional and affective benefits "from having the support of like-minded colleagues. Professional communities provide not only a safe haven, but also a forum in which teachers can engage in inquiry and seek informed opinions about the challenges that arise in the classroom" (p. 92). In their study of a university/school partnership's professional development, Van Dusen, Ross, and Otero (2012) found the understandings of participating teachers evolved as they engaged in collaborative discourse within their communities of practice:

> When we think about professional development programs we often think about bringing expertise and resources to the teachers. We might instead explore the view that the resources necessary for meaningful professional development reside within the teachers and their particular contexts. By leveraging a community's everyday professional experiences and insights to address their shared goals, we can create substantive opportunity for professional growth. (p. 12)

The relationships developed within these communities of practice are vital to supporting the sustainability of university/school partnerships. Mr. Parker, one of the

USMP SCP administrators, stressed the importance of the relationships built within the USMP SCP communities of practice by stating "Without these strong relationships, I do not feel that the program would have sustained itself for as long as it has" (Interview, September, 2014). In a report describing their study of Math and Science Partnerships (MSP), Shapiro and Frank (2010) confirmed that relationship-building was an important factor for MSP sustainability:

> The person-to-person networks and relationships that had been built through the MSP were seen as cornerstones supporting the continued commitment to the MSP work beyond the initial funding period. The investments that were made in individual participants were seen as investments in intellectual/human capital that would continue to pay out. (p. 23)

These findings imply that collaborations within communities of practice contribute greatly to the sustainability of university summer campus programs. Within these professional learning communities, the participants of university summer campus programs can "embrace the transparency of their work, their accomplishments, and their challenges, and they share ideas, insights, and practices as they collaborate in ways that build on individual strengths and overcome individual challenges to ensure mathematical success for all students" (NCTM, 2014, p. 99).

Reflections

As concern intensifies about the national crisis facing the United States as American students rank poorly on international tests measuring mathematics achievement, there is a growing need to find ways to prepare students in mathematics:

> It is critical to realize that financial responses alone won't ultimately safeguard our economic and social well-being, and that substantial, strategic investments in education are essential to our long-term prosperity and to our success as a democracy. We cannot just bail ourselves out of this crisis. We must teach our way out. (Darling-Hammond, 2010, p. 3)

Many attribute the declining mathematics achievement of American students to a lack of skilled teachers and recognize that providing high-quality professional development for mathematics teachers is critical. University/school partnerships have established intensive university summer campus programs to provide opportunities for teachers to gain the mathematical and pedagogical content knowledge required to teach effectively. As the demand increases for high-quality professional development for mathematics teachers, there is a need to understand how university summer campus programs evolve, the factors that impact their evolution, and the components that contribute to the sustainability of these programs.

This research study focused on one particular university summer campus program. This study began with my desire to learn more about the USMP SCP. Although I have been involved with the USMP SCP since 1988, there was a great deal I did not know about the program. Just as a person playing in the orchestra knows his or her own unique part, he or she is not always aware of what goes on backstage to prepare for a musical production. This research project has allowed me to go backstage to get a behind-the-scenes glimpse at the USMP SCP.

Investigating the evolution of the USMP SCP provided me with information about how and why the program evolved. As a participant in the 1988 program, I spent

six weeks with other secondary mathematics teachers learning high-level mathematics that advanced my knowledge of mathematics. However, the mathematics I learned could not be used when I returned to my middle school classroom. Now, twenty-seven years later, I am a master teacher for the current USMP SCP which has evolved into a three-week program for K-12 mathematics teachers that incorporates an active approach to learning mathematics topics which enhance and transcend traditional classroom mathematics, integrates technology and manipulatives into lessons, and places an emphasis on motivation, applications, and problem solving in mathematics.

During this study, I began to understand how certain factors impacted the evolution of the USMP SCP. From the data collected, I was able to identify financial support, changes in the teaching force, accountability, equity, technology, and standards for curriculum as factors impacting the evolution of the USMP SCP. Many of these factors involve social and political issues in America. As university/school partnerships develop summer campus programs for mathematics teachers, they must attend to these issues and be willing to adapt their programs to address the funding requirements as well as the needs of the participating teachers and area school districts.

This study has provided a glimpse into the evolution of the USMP SCP which has helped me understand why this program has been in existence for almost 30 years. I was able to identify several components that contributed to the sustainability of the USMP SCP. These components included faculty and staff, collaboration and adaptability, high-quality professional development, and communities of practice. As other university summer campus programs are designed, it is imperative that a special focus is placed on each of these components. Since the majority of university summer campus programs are

designed as part of university/school partnerships, the key feature of these programs should be on partnerships. The components that have sustained the USMP SCP are all based on developing relationships between the university and area schools and determining the program modifications needed to best meet the needs of the mathematics teachers and their schools.

This research study focused on the evolution of a university summer campus program, the factors that impacted its evolution, and the components that contributed to its sustainability. However, additional research is needed on other aspects of university summer campus programs. The following questions are examples of possible research studies to further explore university summer campus programs:

- What is the correlation between participation in university summer campus programs and teachers' effectiveness in classrooms?
- How does participation in university summer campus programs impact teachers' self-efficacy?

We are currently experiencing a "time of great opportunity for mathematics education in the United States. Lines of communication have been opened among policy makers, mathematicians, and mathematics educators, and changed educational policies provide the potential for educational improvement" (CBMS, 2012, p. 16). Given the critical need to develop and study programs that enhance teachers' mathematical knowledge for teaching, the study of university summer campus programs for mathematics teachers continues to be a worthy topic of research.

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Appendix A

Interview Questions for Administrators of the

University School Mathematics Project's Summer Campus Program

Interview Questions for Administrators of the

University School Mathematics Project's Summer Campus Program

1. From your perspective, describe your role in the University School Mathematics Project's Summer Campus Program (USMP SCP).

2. Describe the evolution of the University School Mathematics Project's Summer Campus Program (USMP SCP) in terms of the ideas below:
    a) In what ways have goals of the USMP SCP evolved?
    b) In what ways has funding of the USMP SCP evolved?
    c) In what ways has curriculum of the USMP SCP evolved?
    d) In what ways have the resources provided for participants of the USMP SCP evolved?
    e) Are there other aspects of the USMP SCP that you can think of that have evolved that I have not mentioned?

3. During your time as an administrator for the USMP SCP, what factors, including social and political factors, were impacting mathematics education?

4. How do you think those factors impacted the evolution of the USMP SCP?

5. The USMP SCP has been in existence for 27 years. Which components of the USMP SCP would you identify as contributing to the sustainability of this program?

Appendix B

Interview Questions for a Focus Group of Master Teachers of the University School Mathematics Project's Summer Campus Program

Interview Questions for a Focus Group of Master Teachers of the University School Mathematics Project's Summer Campus Program

1. During your time as a master teacher in the University School Mathematics Project's Summer Campus Program (USMP SCP):
    a) What were the goals of the USMP SCP and how did they change?
    b) How was the curriculum developed and taught and how did it change?
    c) What resources were given to participants and did those change?
    d) How did the USMP SCP impact you as a mathematics educator?

2. During your time as a master teacher in the USMP SCP, what factors, including social and political factors, were impacting mathematics education?

3. How do you think those factors impacted the USMP SCP?

4. The USMP SCP has been in existence for 27 years. Which components of the USMP SCP would you identify as contributing to the sustainability of this program?

Appendix C

Interview Questions for Participants of the

University School Mathematics Project's Summer Campus Program

Interview Questions for Participants of the

University School Mathematics Project's Summer Campus Program

1. What were your reasons for attending the University School Mathematics Project's Summer Campus Program (USMP SCP)?

2. Tell me about your participation in the University School Mathematics Project's Summer Campus Program (USMP SCP).
    a) What was memorable?
    b) What was included in the curriculum and how was it taught?
    c) What resources were you given?
    d) How did your participation in the USMP SCP impact your students?
    e) How did your participation in the USMP SCP impact you as a mathematics educator?

3. During your time as a participant in the USMP SCP, which factors, including social and political factors, were impacting mathematics education?

4. How do you think those factors impacted the USMP SCP?

5. The USMP SCP has been in existence for 27 years. Which components of the USMP SCP would you identify as contributing to the sustainability of this program?